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Topics of the Month

Rapid growth of Norway's chemical industry

EACH month brings news of some fresh enterprise of Norway's chemical industry, which has made some very significant advances during recent years. At present the Norwegian chemical and electrochemical industries are together responsible for a good 10% of the country's total industrial production. Best known of Norway's chemical producers is Norsk Hydro, which makes good use of the cheap and abundant supply of hydro-electricity for the extraction of nitrogen products. In a country where the *per capita* electricity consumption is the highest in the world, this huge undertaking consumes about 4,000 million kwh.—about 25% of the country's total power production.

There is a tendency to think that the manufacture of nitrogen products is the only Norwegian chemical enterprise of any significance. This is by no means the case. For instance, there is the Norwegian sulphur industry, the international status of which was emphasised during the recent world shortage of this product. With a yearly output of about 100,000 tons of sulphur derived from pyrites, the firm of Orkla Grube Aktiebolag—at present the sole producer—has placed Norway among Europe's leading sulphur producers.

The surprising range of Norway's chemical products is based upon the country's three great natural assets: the energy released in falling water and the riches of the forests and the sea. Possessing both abundant cheap electricity and good supplies of limestone Norway has long been a producer of calcium carbide. Production of 33,000 tons p.a. is the present target. Odda Smelteverk A/S, the largest of the four firms producing calcium carbide, processes a full 80% of its output to calcium cyanamide fertiliser, a big portion of this being exported. Lately this firm has carried its calcium cyanamide refining a step further by producing dicyandiamide. This is exported to Great Britain where it is further processed to melamine for the making of plastics. Norway's three other producers of calcium carbide export their product in crude state.

Against the background of Norway's extensive whaling operations was developed her important contribution to world chemical knowledge in the field of fat processing. As a result of the discoveries made, whale oil has at last gained recognition as a quality raw material for margarine production. Recently, herring oil has also been drawn into this highly developed processing industry and today competes successfully with vegetable oils for a variety of uses. A million-dollar plant to decolorise and fractionate herring oil by the *Solexol* process is nearing completion and expected to go into operation soon. In our January issue, we described a large new plant built by Sanda Fabrikker A/S for

the production of fatty acids by the Armour process which employs a technique similar to that of petroleum refining. Norway produces from 160,000 to 170,000 tons of whale oil and about 60,000 tons of herring oil annually and this provides her fat processing industry with plenty of scope for development.

Norway's forests have long served as a basis for industry. A highly-developed wood processing industry produces not only substantial quantities of cellulose, wood pulp, paper and cardboard but is also constantly developing new products such as cellulose derivatives. Another important Norwegian industry is that of synthetic resins, and 100% phenolic resins, modified phenolic, urea formaldehyde and alkyd resins have been regularly manufactured over the past three years. There is also a soap and detergents industry using modern manufacturing methods, a flourishing cosmetics industry and a rubber industry capable of meeting more that half the country's requirements for rubber tyres and footwear in addition to turning out a series of technical products. Finally there is the well-established Norwegian cement industry which produces 700,000 to 800,000 tons p.a.

Chemical Plant Exhibition preview

THE August issue of CHEMICAL AND PROCESS ENGINEERING will contain an illustrated preview of the plant and equipment to be shown at the Chemical Plant Exhibition, which is being held at Olympia, London, from September 3-17, as part of the Engineering Marine and Welding Exhibition. This special coverage is being given to the Exhibition because it is the first one devoted exclusively to chemical plant to be held in Britain since before the war.

The Chemical Plant Exhibition is being sponsored by the British Chemical Plant Manufacturers' Association and the Director, Dr. E. T. H. Hoblyn, M.B.E., will contribute to our Special Issue. Other distinguished people who, we hope, will contribute to this issue are Sir Harold Hartley, immediate Past-President of the Institution of Chemical Engineers, Mr. H. V. Potter, Chairman of the Chemical Engineering Group of the Society of Chemical Industry and Chairman of Bakelite Ltd., and Mr. J. A. Reavell, Chairman of Kestner Evaporator & Engineering Co. Ltd., and one of the pioneers of chemical engineering in Great Britain, being, for instance, a former Chairman of the British Chemical Plant Manufacturers' Association.

Making lubricating oils last longer

THE National Research Council of Canada has developed a process for making lubricating oils last several times longer. Research by Dr. I. E. Puddington and Dr. A. F. Sirianni, of N.R.C.'s Division of Applied Chemistry, led to the conclusion that hydrocarbon lubricating oils in normal service deteriorate mainly because of oxidation—which can be prevented by adding common chemicals.

Lubricating oils exposed to heat and air are slowly attacked by oxygen, forming hydroperoxides. From there on the deterioration is much more rapid, apparently because of a chain reaction. This second and faster form of oxidation can be stopped by counteracting the materials responsible—hydroperoxides or organic acids—as soon as they are formed. Added materials that can slow down oxidation include " highly positive " metals such as lithium, sodium, potassium and magnesium, or their salts and oxides.

Possible ways of adding the protectives include : attaching a piece of metal to the drain plug, dispersing the material in the oil itself, or impregnating the filter.

This process is available for licensing through Canadian Patents and Development Ltd., Ottawa.

The Kachkaroff-Guareschi sulphuric acid process

TWO plants making sulphuric acid by the Kachkaroff-Guareschi process are being built in England. One, for the South Eastern Gas Board, is at East Greenwich, London, the other, for the East Midlands Coal Board, is at Grassmoor. Each is a 50 ton/day unit and the constructors are Simon-Carves Ltd. The raw material in each case will be spent oxide, but the Kachkaroff process can utilise other sulphur-containing materials such as pyrites, cold gases from copper converters, or gypsum. The process is now being introduced to the United States by International Processes Inc., who inform us that it is designed to replace the old lead-chamber process. Essential elements of the plant are : furnaces, dust precipitator, concentration tower, denitration tower, reaction tower, filter tower, gas and acid coolers.

The mechanical furnaces with the accompanying dust chamber are of conventional design and essentially the same as those in use in the lead-chamber system. The use of an electrostatic dust precipitator or other mechanical means for settling dust is unnecessary where no acid of greater purity than that obtained from lead chamber is required.

Owing to the high concentration of all the acid circulated in the system, the majority of the coolers and pipework are of iron, the use of lead being reduced to a minimum.

In the main system for the production of 78% acid, the burner gases pass directly from the dust chamber to the denitration tower, thence through the several compartments of the reaction tower and finally escape to the atmosphere *via* a small filter absorption tower at the end of the plant. The basis of the process is the reaction, under controlled conditions, between SO_2, O_2 and nitrous vitriol, when solution and oxidation of sulphur dioxide takes place with extreme rapidity and with almost simultaneous regeneration of the nitrous vitriol. Little or no gaseous nitrogen oxides are liberated in this reaction and this accounts for the phenomenally low space-time contact, which allows plants to be constructed with a reaction space of as low as 0.4 cu. ft. per lb. of sulphur per 24 hr. In order to bring the reactants into intimate contact, nitrous acid is circulated over the reaction tower, the heat of reaction being removed by cooling the circulating acid in coolers. Correct nitrosity is maintained by introducing nitric acid or gaseous products of ammonia oxidation and water to the system. The sulphuric acid so formed in the reaction tower results in an increase in volume of the circulating acid and this surplus is bled off to the denitration tower, where by dilution and action of sulphur dioxide the acid is denitrated. The final product is withdrawn at approximately 78% H_2SO_4, which after cooling is pumped to stock or to the concentration tower as requirements demand. Traces of vesicular acid and small quantities of nitrogen oxides may be carried forward in the gases from the reaction tower, and therefore a small filter absorption tower is installed at the end of the system. Sulphuric acid is circulated through this tower in small quantities, the nitrosity being maintained at a constant low value by bleeding out continuously to the denitrating tower and replenishing with denitrated acid as required.

Apart from furnace supervision, the plant is operated by

one man per shift. Automatic regulating valves control the rates of flow under general conditions and normal control only involves the periodic measurement of volume, density and nitrosity of the circulating acid and, where indicated by such readings, adjustments to the rates of water and nitric acid or ammonia feeds. Indeed, it is claimed that process control has proved so simple that it is possible to leave the supervision of the installation to an unskilled operator.

Fertilisers from domestic refuse

IN utilisation of domestic refuse—a problem to which most countries have still to find a satisfactory solution—the Dutch are well ahead. The domestic refuse collected in The Hague is railed to the distant province of Drente where it is stored for several months in large concrete hoppers to undergo partial or complete fermentation. Later it is screened and the screenings are pulverised. The regular demand for this mixture by farmers is twice the supply. Local users speak in the highest terms of the product, saying that it is a good humus former and a stimulant to microbial life which gives their soil a better structure and increases its water holding capacity, with the result that soil erosion is prevented or reduced.

The interesting point about this is that analyses of the refuse pulverised at Drente show that it is comparable with average British refuse, yet pulverised refuse in this country has not so far met with the demand anticipated. Technical opinion differs as to whether a period of pre-fermentation adds substantially to the agricultural value of the Dutch product. Mr. J. C. Dawes, C.B.E., M.I.Mech.E., who recently gave a paper ' The Storage, Collection and Disposal of Domestic Refuse ' before the Institution of Civil Engineers in London, is not convinced that it does. He points out that another, and smaller, pulverising plant is now operating in the Netherlands under the same management, without pre-fermentation.

Another way of making use of refuse is by mixing it with sewage sludge to make compost. During the war a committee of experts was set up by the Agricultural Research Council to study this question and the results of the experiments showed that a good manure could be produced by this means. A ' rapid ' or ' induced fermentation ' method has been used in some districts of Southern France and Italy, and has been tried out by private enterprise in London. There are several systems, but each depends for success on the continuous disposal of the end product at an economic price, as is the case with pulverisation. Given a refuse with a high mineral and low fermentable content, such as is produced in Britain, a costly rapid fermentation system could hardly be expected to succeed. In the London trial referred to, the end product did not command an economic price for agricultural use and the plant was eventually closed down.

Fish by-product processing

DEVELOPMENT of commercial processes for utilising fish by-products is carried out at the Torry Research Station, Aberdeen. Some time ago work was started on an alkali digestion process for reducing herring to oil and animal feedingstuff. This has now been suspended, owing to the recent fall in the price of fish oil and the rise in the price of fish meal. Attention has now been switched to processes which will give maximum quantities of high-grade feedingstuff and yet still produce oil of satisfactory yield and quality. The traditional cook-and-press process is satisfactory provided that problems associated with glut landings can be solved. In effect, this entails the development of efficient storage procedures for the raw material, or possibly for a half-way product, and possible adaptation of the cook-and-press technique to handle the preserved raw material.

Experiments are in progress in which macerated herring are preserved with formaldehyde, or other preservative, and are later cooked and pressed, either in conventional equipment or in novel experimental plant. Alternatively, fresh herring may be cooked and pressed at a rate in excess of plant drying capacity and the press-cake preserved.

Readers of our note on food research in the May issue (p.127) will recall that Torry is one of the research stations of the Food Investigation Organisation of the D.S.I.R. The above information is given in the Organisation's 1952 report which brings up-to-date several of the projects mentioned in our note. Chemical engineering principles underly many of the researches, particularly at Torry where much effort is devoted to freezing and cold storage and the associated problem of heat transfer, to smoke curing, to cold storage of frozen fish, and to air and vacuum drying of fish. Chemical engineering research at the Low Temperature Research Station at Cambridge includes studies of the use of ion exchange for separating plant and animal extracts, the plating of tin on aluminium by chemical displacement, and the control of ozone treatment in air conditioning. The report is published by H.M. Stationery Office at 2s. net.

Glycerin from molasses

IN view of the possibility that synthetic detergents may one day cause a serious reduction in soap manufacture and thus of the production of glycerin, it is extremely interesting to learn that I.C.I.'s Nobel Division has built and is operating a plant for the manufacture of glycerin by fermentation of molasses. A broad hint of I.C.I.'s views on future glycerin supplies is given by the statement that the plant is providing data for ' a proper examination of the technical and economic aspects of large-scale production.'

Fermentation was, until recently, the best known alternative to the saponification of oils for glycerin manufacture. However, in 1948 the Shell Corporation built a plant at Houston, Texas, for the synthesis of glycerin from propylene, incidentally the starting material for the very first synthetic glycerin, made in 1872 by Friedel and Silva. Although there is not as yet any sign that the Shell Corporation in Britain contemplates making glycerin from propylene, this possibility cannot be totally disregarded.

More I.C.I. research

THE news about the glycerin-from-molasses plant is given in I.C.I.'s annual report for 1952. From this it is evident that in spite of the, possibly temporary, improvement in sulphur supplies, the company is still very interested in alternative sources of this element. Thus, they are carrying out work on the production of sulphur and sulphur dioxide by the desulphurisation of anhydrite in a vertical retort. This has been so promising on the laboratory scale that a prototype full-scale retort is to be built.

Another piece of chemical engineering research has been a study of the operational efficiency of vertical shaft lime kilns. This has been very successful and it is claimed that

the output of the experimental kilns was raised very substantially by methods which can be translated satisfactorily into operational practice.

I.C.I. have in the past done considerable work on fluorine products. Two of them—a plastic and a lubricant—are now being made in larger quantities. The plastic is polytetrafluoroethylene. A pioneer plant for its manufacture came into commission last year. Although it is relatively expensive to produce, the polymer has high resistance to most chemicals and combines good electrical properties with a high softening point. The fluorine lubricants have similar high resistance to chemicals and it is claimed that the savings deriving from this property more than compensate for their present high price. It is hoped that the increased output of these lubricants will eventually permit their use in other industries. Hitherto they have been used in I.C.I.'s own works.

Titanium metal is another object of current I.C.I. research. Work on the production and properties of wrought titanium metal has been done by the General Chemicals and Metals Divisions and good progress has been made. The Kroll reactor which is used for large-scale production in the U.S. has been used on a small scale but a promising alternative production method has now been developed in the company's laboratories.

The subsequent processing of titanium and titanium alloy ingots into bar, plate and forgings has been studied, and these wrought forms can now be produced without undue difficulty. The processing into thin sheet, tube and wire requires further research but no insuperable difficulty is foreseen. A plant is being built to produce 100 tons p.a. of wrought titanium metal for the engineering and aircraft industries. At the same time plans are being actively pursued for the construction of a plant to produce some 1,500 tons p.a. of titanium metal in sponge form and to convert this by melting to massive metal.

The 1952 research report ends with some disappointing news about the I.C.I. potash project in Yorkshire. An experimental brinewell was operated throughout 1952 to investigate the extraction of potassium chloride from the deposits as a solution. These tests have now been ended, the conclusion being that this method is unlikely to be successful. The extraction of the deposits by mining has been studied for the company by Prof. J. A. S. Ritson of the Royal School of Mines. His report has been used to make a forecast of the technical problems involved in mining and refining Yorkshire sylvinite and of the economics of the venture. Conclusions similar to Prof. Ritson's have been reached independently by Fisons Ltd., and a statement has been made jointly by the two firms to the Ministry of Materials.

Process stream analyser

CONTINUOUS infra-red analysis of a pilot plant process stream is now possible with a new American instrument designed to monitor the concentration of up to six components in a liquid or gas stream. Absorption is plotted on a multi-point strip chart recorder with a complete cycling time of about 6 min. The entire instrument is mounted in a mobile metal console and may be easily moved to the location of the pilot stream.

The new model can study directly the effect of such variables as temperature, pressure, flow rate, composition, etc., in a process stream. It also determines the dependent and independent components in a stream and the best method of employing infra-red analytical equipment under process stream conditions. Previously, by using a batch sample from a process stream for laboratory analysis, many important components that exist only under stream conditions were missed.

The multi-Component Analyser fills the gap between laboratory spectrometers and process plant stream analysers.

Simpler flow sheets

TRADITIONAL ways of doing things often hamper us when commonsense should rule. As an example, take the way in which Government departments used to word their communications to the public before the recent reform of 'officialese.' Growing public exasperation with these ponderously phrased pamphlets and forms at last wrought a change and now the man in the street can read his income tax forms with comparative ease, if not with pleasure.

In the technical world we are also apt to take it for granted that, in dealing with a complicated subject, explanations must be correspondingly complex. Technical information is often obscured by ponderous jargon instead of being made crystal clear by the proper use of plain English.

Similarly with process flow sheets or control diagrams. Conventional methods of representing pieces of equipment or pipeline are good so long as they make the process clearly understandable; it is when more heed is given to drawing-office conventions than to a clear interpretation of the process that a change of methods is indicated. The engineering drawing, showing the finer details of the plant and the exact disposition of the equipment is essential to the construction engineer or draughtsman, but is only confusing to the site man who merely wants to know the essentials and to be able to refer to them quickly.

Realising this, an American engineer has devised a simple system of showing process flow and control, in which cumbersome conventions are swept away so that the diagram can be easily followed. He is Mr. W. L. Willoughby and he presented his idea at the Symposium on Instrumentation for the Process Industries held in Texas recently. Side by side with a number of conventional diagrams, he showed his own simplified versions, which were indeed strikingly clear.

The chief faults which he found in conventional flow sheets were the confusing line crossings, all intersecting at right-angles, which makes it difficult to see the flow direction; the complicated system of equipment symbols, which in some cases involve the use of several separate symbols for a single piece of equipment; the practice of placing instrument lines parallel with process lines; and the too strict adherence to the actual physical location at the expense of clarity.

To indicate flow direction, he advocated the use of curves for intersections and, to illustrate his point, drew an analogy with the square pattern of street design favoured in U.S. cities. The fact that the streets had the maximum number of intersections, all with square turns (the 'draughtsman's delight') made driving confusing and often meant slowing down at every crossing while coming to a decision. Outside the towns traffic conditions had been greatly improved by the use of one-way traffic lanes and the elimination of square turns. The same principle could be applied to flow diagrams. Another feature of Mr. Willoughby's diagrams is the use of more graphic equipment symbols. For instance, a pump is indicated by a pear-shaped symbol, of which the larger end is the suction end, thus showing clearly the flow direction.

BATCH VERSUS CONTINUOUS DISTILLATION—1

By S. R. M. Ellis, Ph.D., F.R.I.C., A.M.I.Chem.E., and J. T. Shelton, B.Sc.

(*Chemical Engineering Department, University of Birmingham*)

For the separation of binary and multicomponent mixtures, batch and continuous distillation are used, both in the laboratory and on a commercial scale. Continuous distillation is usually selected when large quantities of feed of constant composition are available, but when the quantities are small and the feed composition varies, batch distillation is frequently used. The wider use of automatic control instruments in industry does make possible the greater use of continuous operation for laboratory and pilot-plant distillation. However, the relative merits of the respective operations are often difficult to define and the literature of the subject offers little guidance, for the few references that exist on the relative advantages of batch and continuous distillation are somewhat conflicting in their views. In this paper the authors make an original contribution to the problem by comparing batch and continuous distillation in terms of a constant overhead composition, *i.e.* between a batch still operating at varying reflux ratio and a continuous still operating at constant reflux ratio. Their results and conclusions are extremely interesting, even, perhaps, controversial. Indeed, it is hoped that the paper will provoke discussion and in this connection the Editor cordially invites readers to submit their views in the form of written contributions for publication.

FOR the separation of silicones, 1-3 butadiene and butene and the purification of crude acetophenone Lloyd[1] shows that a higher yield of greater purity product is obtained by using continuous rather than batch distillation. It should be noted that, in the cases quoted, the boiling points of the liquids are close together and the relative volatilities are low, *i.e.* α is less than 1.25. In these investigations packed columns 1 in. to 3 in. in diameter were employed. Unfortunately no H.E.T.P. or H.T.U. calibrations are given for the columns operating batchwise or continuously. Boil-up rates and other experimental operating conditions are also not available. The weight of the conclusions expressed, however, is such as to focus attention on the relative advantages of small-scale continuous distillation. These conclusions are based on a comparison of batch and continuous stills operating at constant reflux ratio.

Rose[2] states there is an advantage in using batch distillation when the feed contains less than 25% of the more volatile component and when the column is initially operated at total reflux, followed by constant reflux and varying overhead composition. The degree of advantage for batch distillation depends partly on the amount of hold-up in the column and partly on the feed composition. When the concentration of the more volatile component is greater than 25%, continuous distillation appears at high yields of the volatile component to give a greater purity product. Rose claims that the advantage for batch distillation becomes more apparent when complete separation is not required. This is particularly so in the removal of small amounts of light volatile components in rectifying operations.

Lloyd[1] has expressed the view that the most favourable condition for batch distillation is when the amount of material in the kettle is small at the time of transition from one fraction to another. This viewpoint would appear to be in conflict with the above comments of Rose.

Perry[3] quotes a comparison between continuous and batch distillation for the separation of a feed of 40 mole % benzene and 60 mole % toluene into a distillate containing 99.5 % benzene and a bottoms product containing 1 mole % benzene. The number of theoretical plates in continuous and batch distillation is the same, *i.e.* 18. Hold-up is neglected and the same time of distillation is assumed. For batch distillation it was found that the required reboiler vaporising capacity and column area was equivalent to 254 moles per hr. Continuous distillation required a boil-up rate of 142 moles per hr.

Thus, in this example, batch distillation requires a larger diameter column and has a higher heat requirement compared with the equivalent duty continuous distillation column. As will be shown later, this conclusion must be limited to the defined operating conditions and is modified by the number of plates in the column, the amount of hold-up in the column and the purity of the products.

It will be appreciated that any comparison between batch and continuous distillation is complicated by the large number of variables involved, *i.e.* bubble cap or packed columns, liquid hold-up effects, varying reflux ratio or constant reflux ratio operation (varying or constant overhead composition), yield of product, composition and amount of feed, time of distillation, etc.

After consideration of the above factors it was decided to make a comparison between batch and continuous distillation in terms of a constant overhead composition, *i.e.* between a batch still operating at varying reflux ratio and a continuous still operating at constant reflux ratio. The choice of a varying reflux ratio for batch distillation was made so that the overall distillation time and heat requirements are a minimum.

The comparison is made for bubble-cap columns with a definite hold-up on each tray and for columns with zero hold-up. Hold-up has been considered only insofar as it affects the yield of product, *i.e.* see equation (1). The influence of hold-up in the column on the curvature of the operating line or on the rate of mass transfer has been neglected in this paper.

The separation of phenol and ortho cresol fractions

This mixture has been selected for investigation because it is nearly an ideal system with a constant relative volatility, *vide* Ellis.[4] Furthermore, it is an interesting commercial problem. In the continuous distillation of phenols it is common practice to take from the first two columns phenol and ortho-cresol-rich fractions. Assuming a refinery produces 5,000 gal. per week of each of these fractions of 80 to 90% purity, it might well be asked, 'Is it advantageous to use batch or continuous distillation for the re-running of these fractions?'

In this paper it is therefore proposed to first of all consider the following separations:

(*a*) A feed composition of 80% phenol and 20% ortho cresol to give a product of 99.5% pure phenol.

(*b*) A feed composition of 20% phenol and 80% ortho cresol to give a product of 99.5% pure phenol.

The procedure has been to select a column with a given number of plates and

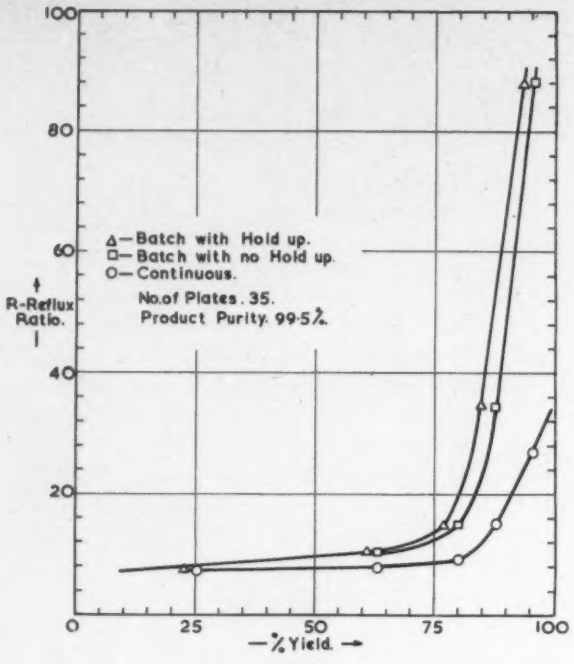

FIG. 1.

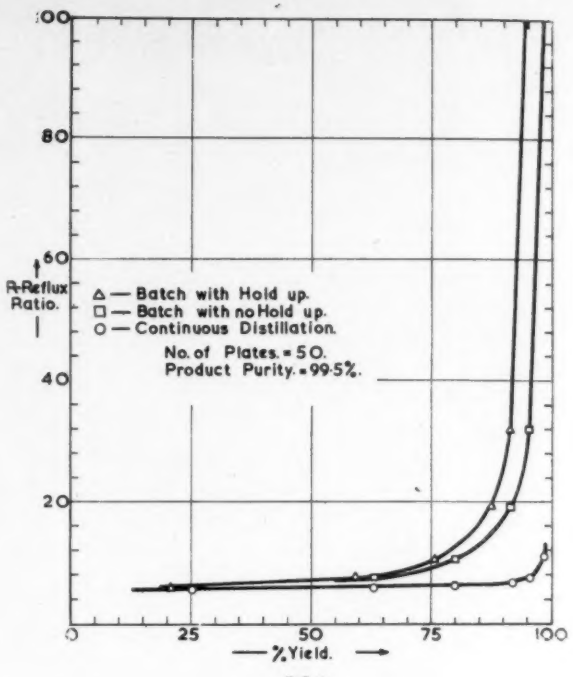
Δ — Batch with Hold up.
□ — Batch with no Hold up.
O — Continuous Distillation.
No. of Plates. = 50.
Product Purity. = 99·5%.
R-Reflux Ratio.
—% Yield. →

FIG. 2.

Table 1. Thirty-five theoretical plates

x_D	x_w	Yield	S	Sm	Rm	R	Method of operation
99.5	75.0	22.6	36	19.7	5.5	7.3	Batch
99.5	60.0	61.0	36	23.1	7.0	10.6	
99.5	45.0	77.0	36	25.9	9.3	15.2	
99.5	25.0	89.5	36	30.0	16.8	34.6	
99.5	15.0	93.2	36	33.1	28.0	88.2	
99.5	75.0	25.3	36	19.7	5.2	7.4	Continuous
99.5	60.0	63.0	36	23.1	5.2	7.7	
99.5	45.0	80.0	36	25.9	5.2	9.3	
99.5	25.0	91.4	36	30.0	5.2	15.3	
99.5	15.0	95.6	36	33.1	5.2	27.2	

Table 2. Fifty theoretical plates

x_D	x_w	Yield	S	Sm	Rm	R	Method of operation
99.5	75.0	21.2	51	19.7	5.5	5.7	Batch
99.5	60.0	59.5	51	23.1	7.0	7.65	
99.5	45.0	75.5	51	25.9	9.3	10.5	
99.5	25.0	87.5	51	30.0	16.8	19.2	
99.5	15.0	91.5	51	33.1	28.0	32.0	
99.5	5.0	94.5	51	38.8	80.4	107.5	
99.5	75.0	25.3	51	19.7	5.2	5.6	Continuous
99.5	60.0	63.0	51	23.1	5.2	5.8	
99.5	45.0	80.0	51	25.9	5.2	6.2	
99.5	25.0	91.7	51	30.0	5.2	7.0	
99.5	15.0	95.6	51	33.1	5.2	7.6	
99.5	5.0	98.8	51	38.8	5.2	11.4	

Table 3. Seventy theoretical plates

x_D	x_w	Yield	S	Sm	Rm	R	Method of operation
99.5	75.0	20.4	71	19.7	5.5	5.5*	Batch
99.5	60.0	57.0	71	23.1	7.0	7.0*	
99.5	45.0	74.2	71	25.9	9.3	9.3*	
99.5	25.0	86.0	71	30.0	16.8	16.8*	
99.5	15.0	90.0	71	33.1	28.0	28.0*	
99.5	5.0	93.0	71	38.8	80.4	80.4*	
99.5	75.0	25.3	71	19.7	5.2	5.4	Continuous
99.5	60.0	63.0	71	23.1	5.2	5.4	
99.5	45.0	80.0	71	25.9	5.2	5.5	
99.5	25.0	91.7	71	30.0	5.2	5.7	
99.5	15.0	95.6	71	33.1	5.2	5.9	
99.5	5.0	98.8	71	38.8	5.2	6.5	

*Approximate reflux ratio

for varying yields of product to calculate the necessary reflux ratio. The average reflux ratio required for batch distillation is then compared with the reflux ratio required for continuous distillation.

For batch distillation the yield and reflux ratio are calculated as follows.

Yield

Bogart,[5] Edgeworth-Johnstone[6] and Ju Chin Chu[7] have given methods for calculating the yield of the volatile component in batch distillation when the reflux ratio is continuously increased to give a constant overhead composition.

Edgeworth-Johnstone[6] has proposed the following equation for calculating the yield:

$$\text{Yield} = \frac{x_p\left[(x_f - x_w) - q(\Sigma - Nx_w)\right]}{x_f(x_p - x_w)} \quad \ldots (1)$$

where x_p = product;
x_w = residue;
x_f = feed;
$q = \frac{Q}{F}$;
Q = mols of material held up in the column per theoretical plate;
F = total mols of charge;
N = number of theoretical plates in the column; and
Σ = sum of liquid plate compositions.

For a low relative volatility and a large number of plates Σ the sum of the liquid plate compositions can be expressed as $N\frac{(x_p + x_w)}{2}$. Equation (1) can thus be expressed as:

$$\text{Yield} = \frac{x_p\left[(x_f - x_w) - qN\dfrac{(x_p - x_w)}{2}\right]}{x_f(x_p - x_w)} \quad \ldots (2)$$

In this paper, equation (2) has been used for calculating the yield of batch distillation.

Reflux ratio

For batch distillation when the relative volatility is low and there are a large number of plates in the column, the graphical McCabe Thiele construction is difficult to employ. The operating reflux ratio can, however, be accurately calculated by the algebraic expressions of Dodge and Huffman[8] or Smoker.[9] The use of such equations is time-consuming and requires a high degree of arithmetical accuracy. Gilliland's[10] empirical correlation, involving the number of plates, the reflux ratio and the corresponding minimum plate and reflux requirements, is a means of rapidly calculating the reflux ratio in continuous distillation. This correlation has been extended to batch distillation and the location of the feed plate in continuous distillation. Details of this method are to be published in the near future.

The procedure used in this paper for the calculation of reflux ratio is as follows:

(*a*) To determine the minimum reflux ratio using Underwood's[11] equation, *i.e.*

$$Rm = \frac{1}{\alpha - 1}\left(\frac{x_{pp}}{x_{wp}} - \alpha\frac{x_{pc}}{x_{wc}}\right) \quad \ldots (3)$$

where Rm = minimum reflux ratio;
α = relative volatility of phenol to o-cresol in the still;
x_{pp} = mole fraction of phenol in the product;
x_{wp} = mole fraction of phenol in the still;
x_{pc} = mole fraction of o-cresol in the product; and
x_{wc} = mole fraction of o-cresol in the still.

(*b*) To determine the minimum number of plates in the column using the Fenske[12] equation:

$$Sm = n + 1 = \frac{ln\ \dfrac{x_{p-p}}{x_{p-c}} \cdot \dfrac{x_{w-c}}{x_{w-p}}}{ln\ \alpha_{av}} \quad \ldots (4)$$

where n = number of theoretical plates in the column;
x_{p-p}, x_{w-p}, x_{p-c}, x_{w-c}, as for Rm; and
α_{av} = log mean average relative volatility between x_p and x_w.

(*c*) Knowing S and Sm to evaluate $\dfrac{S - Sm}{S + 1}$ and from the appropriate correlating curve to determine $\dfrac{R - Rm}{R + 1}$. Knowing Rm, R can be rapidly calculated.

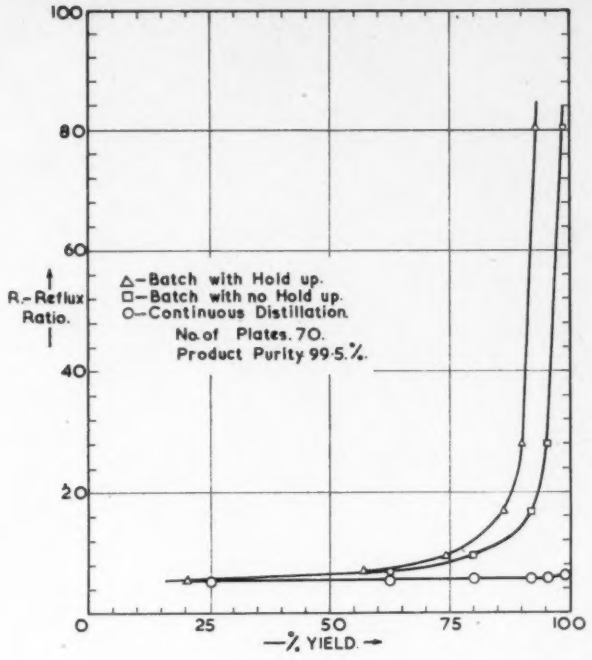

FIG. 3.

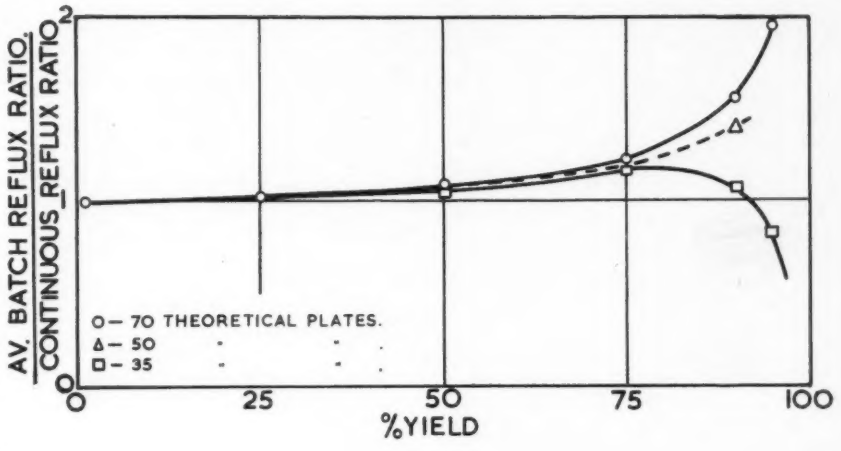

FIG.4.

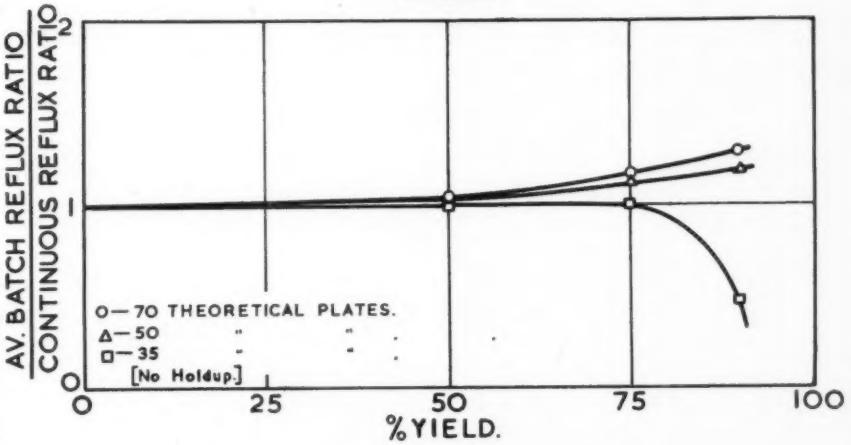

FIG.5.

In the case of continuous distillation the yield can be determined by the following equation:

$$\text{Yield} = \frac{x_p(x_F - x_w)}{x_F(x_p - x_w)} \quad \ldots\ldots (5)$$

where x_p, x_F, x_w, are the product, feed and bottoms compositions. Equation (5) can also be used to calculate the yield in batch distillation when the hold-up in the column is neglected.

For continuous distillation for a given number of plates in the column the reflux ratio was evaluated using Gilliland's[10] correlation. The minimum reflux ratio was determined using the Underwood[11] equation and the minimum number of plates determined by the Fenske equation.[12]

Feed: 80% phenol, 20% o-cresol
Product: 99.5% phenol

Columns of 70, 50 and 35 theoretical plates were selected with an assumed $\frac{Q}{F}$ value of 0.0007. This value is low, but becomes significant in the yield calculations owing to the large number of plates in the column. The reflux ratio and yield calculations are tabulated in Tables 1, 2 and 3.

Discussion of results

The results from Tables 1, 2 and 3 are shown graphically in Figs. 1, 2 and 3.

The final comparison has been made between the reflux ratio for continuous distillation and the average or integrated reflux ratio for batch distillation. The former (*Rc*) was read directly from Figs. 1, 2 and 3 for a given yield. In the case of batch distillation, the average height of the curve, *i.e.* av. R_B, was calculated for the same yield. The ratio $\frac{\text{av. } R_B}{R_C}$ *versus* yield is plotted on Figs. 4 and 5.

Fig. 4 indicates that, when the comparison is made with a small number of plates in the column (and in fact this number of plates approaches the minimum number), batch distillation has an advantage in terms of heat requirements when the yield of overhead product is high. When, however, the comparison is made with a large number of plates in the column and the operating reflux ratio approaches the minimum reflux ratio, continuous distillation has the lowest reflux requirements.

Fig. 4 does emphasise the important fact not previously stated that any comparison between batch and continuous distillation must take into account the number of theoretical stages in the column.

Fig. 5 is interesting insofar that, when hold-up in the column is neglected, or is a minimum as in some packed distillation columns, the advantage for continuous distillation over batch distillation decreases.

It is hoped in Part II of this paper to give a comparison between batch and continuous distillation when the feed composition is 20% phenol and 80% ortho cresol.

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Ammoniation of Superphosphate

ALTHOUGH it is 80 years since McDougal proposed the use of superphosphate for absorbing ammonia from coal gas, it was not until the early 1920s, when the development of the synthetic ammonia process made anhydrous or aqueous ammonia freely and cheaply available, that fertiliser manufacturers in the U.S. began to make use of ammonia as a source of nitrogen in their compound fertilisers. Consumption expanded rapidly and by 1951 the use of ammonia in the form of aqueous and anhydrous ammonia, ammoniating solutions, etc., had so increased as to provide over 50% of the 545,000 short tons of nitrogen used in compound fertilisers.

In Britain there does not appear to have been any substantial manufacture of ammoniated superphosphate until 1952 when ammoniation was practised on quite a large scale by Scottish Agricultural Industries Ltd. By the end of the current fertiliser year this company hopes to produce approximately 90,000 tons of ammoniated granular fertiliser.

A representative of S.A.I., Mr. J. Angus, B.Sc., A.R.I.C., recently presented a paper, 'Ammoniation of Superphosphate,' before a meeting of the Fertiliser Society.

Mr. Angus listed the following advantages of ammoniation:

(*a*) It provides a means of reducing costs. An examination of various fertiliser materials both here and in the U.S. shows a substantial advantage in favour of aqueous ammonia. In addition, there is a probability of substantial savings in handling charges at the receiving works, because it is usually cheaper to receive and handle liquids than solids, especially if the latter are received in bags.

(*b*) It helps to effect a higher degree of concentration in compounds. Anhydrous ammonia which contains 82.4% nitrogen is four times more concentrated than sulphate of ammonia, while the ammoniating solutions contain as much as twice the nitrogen content of sulphate of ammonia and even 30% aqueous ammonia is 1.2 times as concentrated in respect of nitrogen as is sulphate of ammonia.

(*c*) It can improve the physical character of powder compounds and in the case of granular compounds it prevents bag rot.

(*d*) By neutralising the free acid in superphosphate, it permits the incorporation of nitrates in granular compound fertilisers. This opens up the possibility of using ammonia/ammonium nitrate solutions in U.K. granular compounds with resulting advantage in cost and concentration.

(*e*) It makes possible the use of an indigenous material which would otherwise go to waste as unrecovered by-product and prevents associated nuisance.

With these considerations in mind and as a result of the observations drawn from their experiments, S.A.I. decided that they would try to produce all their make of compounds in ammoniated form. For domestic reasons, it was decided to apply this conclusion at only three of their works. At two of the works, one employing a pan-type and the other a tube-type plant, a by-product liquor testing 25 to 28% NH_3, 0.3% CO_2 and 0.01% H_2S was used. The third plant, of the tube type, uses a by-product liquor testing 14 to 16% NH_3, 16% CO_2 and 1.1% H_2S. The pan-type plant has proved the most successful and has produced quite a good granular product. The method of operation developed at this works is roughly as follows:

Ammonia, stored in two old Lancashire boilers, is run by gravity to an 800-gal. header tank over the granulation plant. This feeds a vented tank fitted with a sight glass and calibrated from 0 to 15 gal. Normal usage is from 7 to 10 gal./batch, depending on the superphosphate content of the compound being made. Water is sprayed into the mixer at the same time as the 16-cwt. batch is being brought up the skip hoist. This gives a wet surface to the pan receiving the dry ingredients. As soon as the batch has been tipped into the mixer, the ammonia is run in through an open-ended pipe which discharges under the level of the mixture and immediately behind a plough so that it is very quickly mixed through the batch. The whole of the ammonia is added without interruption. While ammonia is being added, water is sprayed on and, of course, stirring allowed to continue. Heat is evolved during the mixing, the temperature rise being 10 to 12°F. The time of granulation in the pan is about 3.5 to 4 min.

From the mixer the granules pass to the rotary drier, where they are dried to a moisture content of 2.5 to 3%, rising to a temperature of 200°F. in the drier and thereafter being cooled to 80 to 90°F. before passing to storage.

EVAPORATION

Heat transfer in evaporators; current uses in the chemical industry; high vacuum concentration; vapour recompression; scale problems; new equipment

By J. M. Coulson, M.A., Ph.D., A.M.I.Chem.E.
(Reader in Chemical Engineering, Imperial College, University of London)

SINCE the review in this journal last year,[1] the general trend of articles on evaporators in the technical press has been much on the lines of previous years and no very revolutionary development has been noted. On the whole, there has been rather less to report on actual installations in the sugar industry, but there have been more articles giving the general picture of evaporators in the chemical industry. There seems to be a steady increase in the popularity of the climbing- and falling-film units referred to last year, and there is a welcome series of papers on the heat transfer coefficients in these units, although there is a long way to go before the picture is really clear. One or two other articles on heat transfer to boiling liquids serve to emphasise that this subject is far from solved. There is still interest in operation under high vacuum, not only to minimise decomposition but also to reduce corrosion. Other papers cover such problems as scale formation, economics of maintenance and initial outlay, and the general question of providing the best equipment for vacuum production. It is convenient to consider the work of the past year broadly under the headings of evaporators in the chemical industry, high-vacuum techniques, and papers on the heat transfer to boiling liquids.

Evaporators in the chemical industry

There have been two or three papers describing the manufacture of ammonium nitrate, and in each of these the evaporator system is given considerable attention. Shearon and Dunwoody[2] describe the plant at the Mississippi Chemical Corporation in which a large prilling tower is used to give the final crystals. Saeman, McCamy and Houston[3] give a corresponding paper describing the plant of the Tennessee Valley Authority in which continuous vacuum crystallising evaporators are used. It is interesting to compare the three main processes of graining, crystallising and prilling used to obtain ammonium nitrate crystals. There are three main considerations in producing the crystals on a large scale: the economy of operation, the initial investment and the question of safety. Graining is regarded as costly and potentially dangerous, as a temperature of about 305°F. is used. Moreover, it gives crystals of a wide range in size and with the average smaller than that preferred for fertiliser work. Crystallisation is relatively safe with temperatures not exceeding 160°F. and is less costly, and has the added advantage of giving crystals of good form. The equipment is, however, relatively costly to install. Both investment and operating costs are said to be lower for the prilling method. A simplified comparison of the equipment, taken from Shearon and Dunwoody's paper, is given in Table 1.

The prilling process consists essentially in spraying hot concentrated ammonium nitrate liquor from the top of a tower and allowing the droplets to descend against a counter-current stream of air at a lower temperature, thus forming particles of about $\frac{1}{16}$ to $\frac{3}{32}$ in. in diameter. In the Mississippi plant the ammonia in liquid form at a pressure of 180 p.s.i. is vaporised before entering the neutraliser. The temperature in the neutraliser is about 267°F. and a liquor of about 81% strength is obtained. The acid used is 55% nitric and, if stronger, the temperature in the neutraliser will rise. Evaporation is effected in a stainless-steel evaporator of the long-tube, single-effect recirculation type made by the General American Transportation Corporation. The evaporator removes about 2,040 lb. hr. of water for a daily production of 140 tons. The unit operates at a vacuum of 17 in. mercury and concentrates to 95%. The evaporator is one of the key items of equipment, since high temperatures may lead to decomposition. As a protection, a high-temperature cut-off closes the steam when the temperature reaches 290°F. There are considered to be some advantages in using multiple effects, as they give rather smoother operation and easier control of the solution going to the prilling tower. The single unit used here has been very satisfactory when operating at high rates, but at low rates is more difficult to control than the multiple-effect system. Details of the performance of the prilling tower, together with information on the drying time and nature of the crystals formed, are given in the article.

In the second paper[3] the vacuum crystallisation process is described. Here, anhydrous ammonia is reacted with 42.5% nitric acid to give an ammonium nitrate solution of about 56%. This solution is then concentrated in four forced-circulation evaporators each with a capacity of 7,000 lb./hr. at an absolute pressure of 2.4 in. mercury. Control of the temperature in the evaporators is by automatic regulation of the steam supply, and the concentration of the ammonium nitrate liquor is governed by automatic regulation of the flow of water to the barometric condenser. The liquor leaves the evaporators at a concentration of about 79% and a temperature of 140°F., corresponding to about 1% under saturation. This article gives a good account of the crystallisers and other plant items.

These two articles illustrate the common problem of determining the best method

Table 1. Comparison of ammonium nitrate processes

	Graining	*Crystallising*	*Prilling*
Equipment ..	Open-pan evaporators, graining kettles, coolers.	Vacuum evaporators, crystallisers, driers, centrifuges.	Vacuum evaporator, prilling tower, cooler.
Method ..	Open-pan evaporation. Graining in stirred kettles.	Continuous vacuum evaporation and crystallisation.	Solidification of strong solution in current of cool air.
Temperature	305 to 310°	160°	260 to 285°
Particle size ..	−12+35 mesh	−16+35 mesh	−8+20 mesh
Particle shape	Rounded granules	Rounded crystals, or cylindrical with rounded ends	Spherical balls

From Shearon and Dunwoody.[2]

of procedure when two or more good methods are available. Concentration of liquors, particularly where crystals are formed as the final product, offers plenty of scope for experience and virtuosity in design. Of a somewhat similar nature is the report on the ammonium sulphate plant recently erected in India, where the whole plant is described.[4]

Chemicals from milk

Kastens and Baldauski[5] describe the production of chemicals from milk at the Sheffield Farms Co., of Norwich, New Jersey. The milk is warmed to about 90°F. and passed through solid bowl separators where about 8 to 10% is passed out as high-fat cream. The skimmed milk is treated with hydrochloric acid to give the curd used in the casein plant. The whey obtained from these processes is then used in the plant as the basis of a chemical industry. This whey, which contains about 6% lactose, proteins and inorganic salts, is treated with milk of lime to give calcium albuminate which is filtered off through a plate and frame press. The filtrate, which can be considered a sugar liquor, is then concentrated in a triple-effect stainless-steel evaporator from 6 to 40% solids. This unit, made by the Hennszey Co., has 198 tubes 1½ in. by 12 ft., and evaporates off about 25,000 lb./hr. of water with a final vacuum of about 26 in. mercury. The liquor is then treated with direct steam, filtered through a resin filter medium and finally concentrated to 60% solids in a finishing pan of similar construction to the individual units of the triple effect, but with only 150 tubes. Working again under a vacuum, the evaporation here is about 6,000 lb./hr. The thick syrup is crystallised, filtered and dried to give lactose.

Lactic acid from corn sugar

Inskeep, Taylor and Breitzke[6] give a detailed account of the manufacture of lactic acid from corn sugar. In this process the bleached calcium lactate liquor is concentrated from 8 to 50% in a stainless-steel evaporator with a heating surface of 399 sq. ft. This single-effect unit gives an evaporation of from 2,000 to 6,000 lb./hr. of water, depending on the conditions of the tubes, as severe scaling occurs here. The use of a long-tube evaporator for the concentration of silver nitrate to 85% solids is described[7] where the tubes are 10 ft. long by 1 in. i.d.

Glue manufacture

Hull and Bangert[8] describe the manufacture of animal glue at the Consolidated Chemical Industries' plant. Here the hides are given a preliminary treatment such as washing and liming to give the weak glue solution, which is concentrated in a four-bodied, three-effect evaporator unit supplied by the Swenson Evaporator Co. The evaporators are 24 ft. in overall height and the shells and heads are of cast

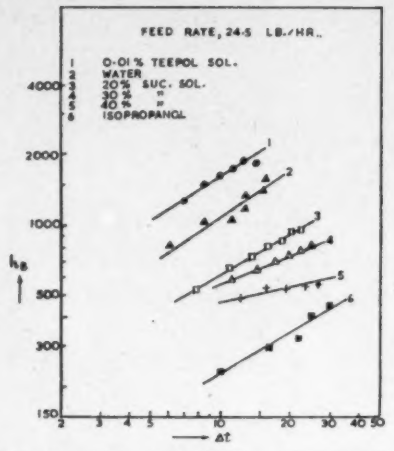


Fig. 1. Influence of film temperature difference on boiling film coefficient

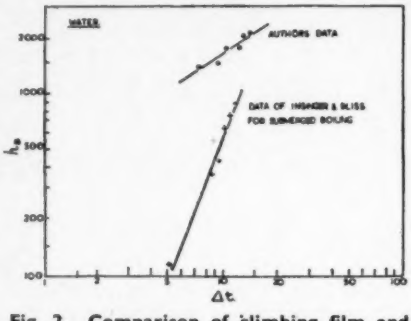


Fig. 2. Comparison of climbing film and submerged boiling for water

iron. Each effect has 250 tubes 16-ft. long and varying from 1¼ to 2 in. in diameter. In three of the effects the tubes are of copper, whilst stainless steel is used for the fourth thick-liquor pan. The condenser has 880 tubes of ⅞ in. diameter by 10-ft. long, giving a surface of 2,500 sq. ft. The whole unit handles daily some 500,000 lb. of bone glue liquors containing about 6.5% glue, together with 160,000 lb. of hide glue liquor of 5% concentration.

There have been rather fewer references to the evaporators in the sugar industry, but Chapman[9] gives a general survey of recent improvements in refining, in which he emphasises the tendency for a reduction in the retention time in the evaporators. He also refers to the arrangements for operating on single pass when on full load and some recirculation when not fully loaded. This question of recirculation is discussed later, but there seems to be some confusion from the reports as to the real merit of this method of working.

High vacuum concentration

Some of the advantages of low-temperature operation, particularly for fruit juices, were referred to last year. Kelly[10] has now given a general paper on the advantages of this technique for more general use in the chemical industry. From the standpoint of heat utilisation Kelly shows that a single-effect unit working at low temperatures on the heat pump principle is equivalent in economy to a four-effect system of normal design. In such a system the low-temperature cooling water for the condenser is obtained from a refrigerating machine. The refrigerator condenser is cooled by water which is then used as heating medium for the evaporator. In this way the heat extracted from the condensing vapour is recovered and re-applied to the boiling of the liquor in the calandria. He discusses some of the advantages of this system as compared with the straight thermocompression unit where the volume of vapour to be compressed is larger. In considering the installation of these units, the influence of any boiling point rise of the liquor must be watched. With organic liquors this will usually be low and by operating at low temperatures the rise is much reduced for inorganics. Besides the merits of preservation of heat-sensitive materials by rapid evaporation at low temperature, Kelly puts forward the proposal that there is much less corrosion as a result of the low temperatures. In experiments with a pilot-plant unit he finds that the scale problem is also reduced. In this unit of three effects the temperatures are normally 75°F. in the first, 62° in the second and 50° in the third.

As an illustration of the reduction in corrosion, the corrosion of mild steel by a salt solution is considered where the rate of corrosion at 20°C. is only about 25% of that at 60°C. There will be occasions, as for instance when using lead, when the increase in the structural strength of the material at the lower temperature is of considerable practical value. In tests on the concentration of black liquor from the pulp industry it was found that working under these conditions of low temperature the rate of build up of scale was very much reduced. Again in a test unit concentrating caustic soda to 35%, caustic embrittlement had not occurred, presumably because the temperature was only 150°F.

Vapour recompression for small-capacity salt units

In the refining of salt it is customary to use multiple-effect units, but when the capacity of the plant is small (*i.e.* less than, say, 50 tons/day), the capital outlay of this type of plant is rather excessive. As an alternative, a small vapour recompression unit using a diesel-engined compressor has been developed[11] by the Manistee Iron Works of Michigan. One unit with a capacity of 24 tons/day has a 340-h.p. diesel engine, and units with a capacity of 100 tons requiring a 1,000-h.p. engine are projected. The diesel engine supplies process heat from both the cooling system and the exhaust, as well as driving the rotary vapour compressor. These units are fitted with continuous centrifuge salt filter and a vertical stack drier down which the salt falls. The whole equipment can be regarded as a packaged unit, which is very suitable for many localities.

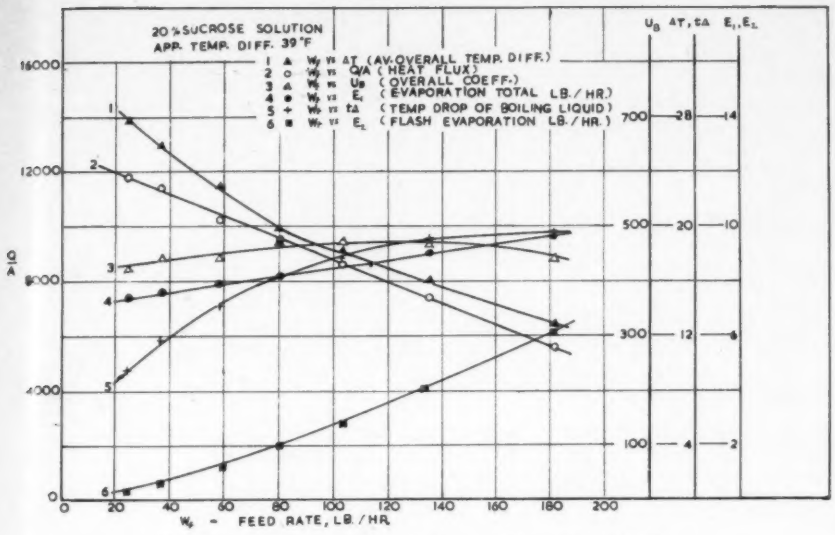

20% SUCROSE SOLUTION
APP. TEMP. DIFF. 39°F
1 ▲ Wf vs ΔT (AV. OVERALL TEMP. DIFF.)
2 ○ Wf vs Q/A (HEAT FLUX)
3 △ Wf vs UB (OVERALL COEFF.)
4 ● Wf vs Ef (EVAPORATION TOTAL LB./HR.)
5 + Wf vs tΔ (TEMP DROP OF BOILING LIQUID)
6 ■ Wf vs Ef (FLASH EVAPORATION LB./HR.)
UB ΔT, tΔ Ef, Ef
Q/A
Wf - FEED RATE, LB./HR.

Fig. 3. Influence of feed rate on working of evaporator

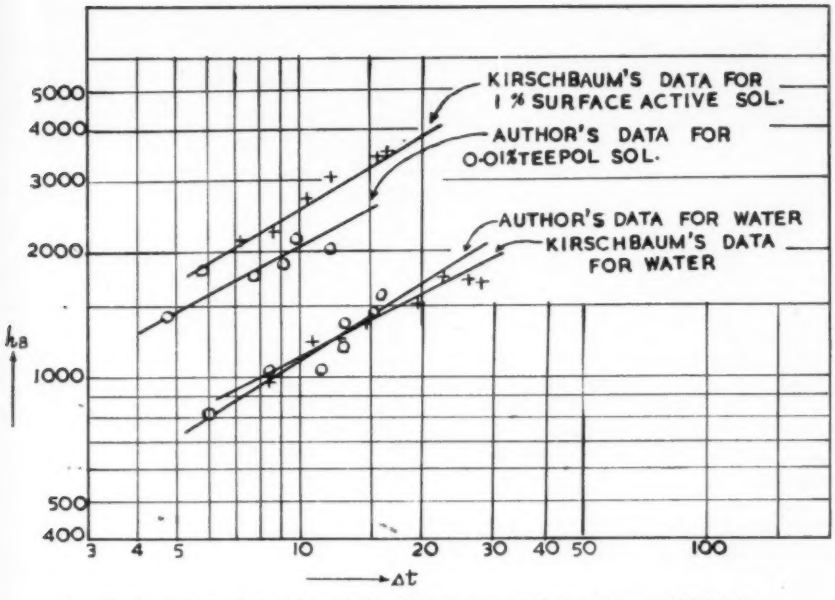

KIRSCHBAUM'S DATA FOR 1 % SURFACE ACTIVE SOL.
AUTHOR'S DATA FOR 0·01% TEEPOL SOL.
AUTHOR'S DATA FOR WATER
KIRSCHBAUM'S DATA FOR WATER
hB
Δt

Fig.4. Comparison of work by Kirschbaum and Coulson and Mehta[11]

Heat transfer coefficients and heat flux

In addition to the more general papers on heat transmission to boiling liquids, two or three papers have been presented during the year on heat transfer coefficients in experimental climbing-film evaporators. Coulson and Mehta[11] used a 5-ft. stainless-steel tube of $\frac{1}{2}$ in. i.d. and give figures for the boiling under vacuum of water, *Teepol* solutions, sucrose solutions and for iso-propyl alcohol. The feed was heated to its boiling point before entering the evaporator tube, thus eliminating the problem of separating the tube into heating and boiling sections where the action is quite different. They heated the tube by circulating hot water at high velocity through a small outer annulus. By passing water at a series of velocities through the inner tube and using a Wilson plot technique, they were able to determine the film coefficient in the annulus. From measurements of the overall coefficient when evaporating the various solutions they were then able to deduce the film coefficient on the boiling side. They examined the effect of temperature difference across the film $\triangle t$, feed rate W_f, and the viscosity of the liquid (μ) on the boiling film coefficient h_b and were able to express their results in the form:

$$h_b = \varphi\left[\triangle t^{0.6} \cdot W_f^{0.25} \cdot \mu^{-0.49}\right] \ldots\ldots (1)$$

The index on $\triangle t$ is small, so that high values of temperature difference do not give substantially greater values of h_b. As shown in Fig. 1, taken from their work, the great value of the climbing-film system is that high values of h_b are obtained with small temperature difference. This means that it is unnecessary to use high temperatures on the surface of the heating tube, which is helpful with heat-sensitive materials. It also enables more effects to be worked between a given overall temperature limit than with other types of evaporator requiring greater temperature difference across each effect. In Fig. 2 their results for water are compared with those of Insinger and Bliss for boiling on a submerged surface, when the merits of the climbing-film system are at once apparent. The authors bring out the interrelation of many of the factors controlling the heat transfer in this form of unit and show how difficult it is to measure the influence of each term directly. Fig. 3 shows the general effect of altering the variables on the performance of the unit when using a sucrose solution and a heating medium at constant temperature, as is likely in practice. It is seen that, whilst the overall evaporation and overall transfer coefficient increase but slightly with increasing feed rate, the actual heat flux falls very considerably. They did not find any falling off in transfer coefficient with increasing percentage evaporation to the maximum value used of 65%. This suggests that recirculation in this type of unit is of little value. Working under a vacuum the drop in pressure over the apparatus was considerable, but this might be improved with a different type of separator.

Kirschbaum[12] has also given data on this form of unit, using a vertical copper tube $1\frac{1}{2}$ m. long by 3 cm. i.d. heated on the outside by steam condensing in an annulus. He obtained values of the boiling film coefficient by direct measurement of the wall temperature using very fine thermocouples inserted in the wall which was 4 mm. thick. Some of his values are shown in Fig. 4, where it is seen that the results by the two authors are in good agreement. Kirschbaum raises the interesting idea that higher values of heat flux are obtained with dilute solutions than with water. Thus he quotes a value of 5,100 Kcal./sq.m./hr./°C. for water and 10,000 for a 20% glycerol solution. Further increase in concentration of the glycerol reduced the transfer coefficient. He further suggests that the high values of heat flux are due to foaming and that the action may be akin to the increased rate of condensation of a vapour when dropwise condensation occurs as compared with film condensation. Kirschbaum gives $h_b \propto \triangle t^{0.41}$ which compares well with equation (1).

Shunichi and Uchida[13] have given results for evaporation in tubes of 2.5 m. long and 11.9, 18.6 and 25.5 mm. bore, using water and methanol. They give an equation for the overall coefficient of heat transfer based on the total length of the tube, but as the feed was cold it is difficult to apply their results or to compare them with those given above.

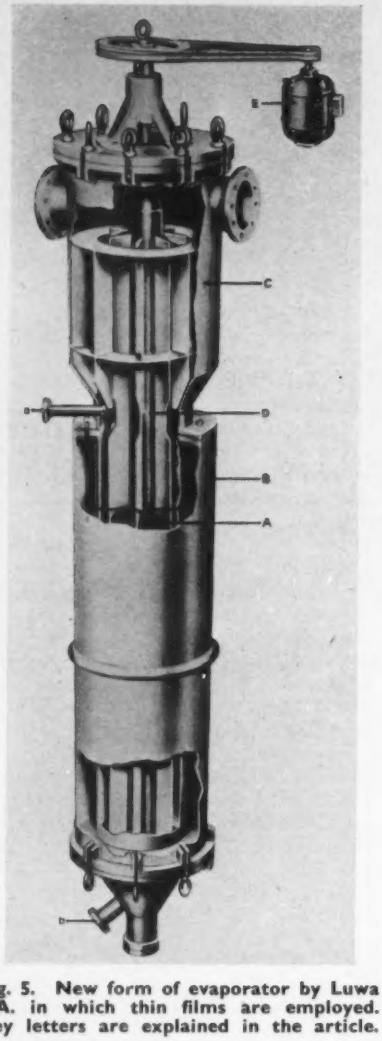


Fig. 5. New form of evaporator by Luwa S.A. in which thin films are employed. Key letters are explained in the article.

General data on heat transfer

Davies[14] outlines some methods for getting an approximate idea of the heat transfer coefficient for various equipments. For forced-circulation evaporators he suggests that the ordinary equation for heating in tubes may be used, but in the writer's experience this will almost certainly give very conservative results. His proposals for standard vertical evaporators are simple and quick, but are based on the rather old data of Badger. For liquids boiling at high pressures he suggests that the boiling film coefficient increases by 100% for each 10°F. rise in temperature. Myers and Jarzombek[15] give a simple nomogram for finding the boiling point rise of an aqueous solution and direct readings can be made for 22 solutions.

For those interested in the fundamental problems and mechanism of boiling liquids, a paper by Rohsenow is instructive.[16] He gives a good summary of our present knowledge of the mechanism of boiling and goes on to develop a new correlation based on the actual physical properties and motion of the bubbles forming from the heating surface.

Although his final correlation is rather complex for practical purposes it does bring out the complexity of the problem and indicates the relative magnitude of the various factors. It would have been useful to have had his correlation compared with those previously given.

Scale problems

Some of the problems of scaling have been mentioned above and a particularly interesting technique for dealing with this problem is described in *Chemical Engineering*.[18] In this unit, as used at the Lake States Yeast Corporation, the Rosenblad switching system is adopted. In this system flat plates are used as the heating element and steam and liquor are alternately passed over the same surface every 8 hr. In this way the tendency for scale formation is much reduced and scale forming in one period is removed by the steam. A triple-effect unit working at 25 p.s.i.g. and 26 in. of vacuum evaporates 33,000 lb. hr. with a steam economy of 3.18 lb. of water per lb. of steam.

Economics

In an interesting article on the economics of buying and maintaining chemical plants, Leonard[19] suggests that multiple-effect evaporators are relatively cheap. The main maintenance problems are the replacing of steam tubes, the removal of scale and the repair of salt-removing equipment. For batch evaporators which are frequently used for corrosive liquors, expensive materials of construction may be used and he suggests that re-lining at two-year intervals at two-thirds of the initial cost may be necessary. This he suggests is equivalent to $800 per 1,000 gal. of liquor per year.

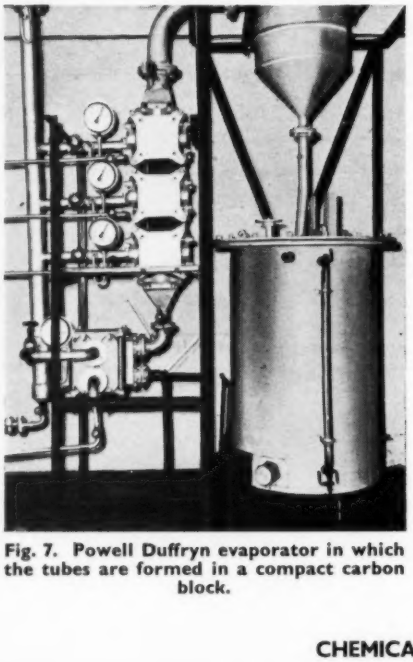


Fig. 7. Powell Duffryn evaporator in which the tubes are formed in a compact carbon block.

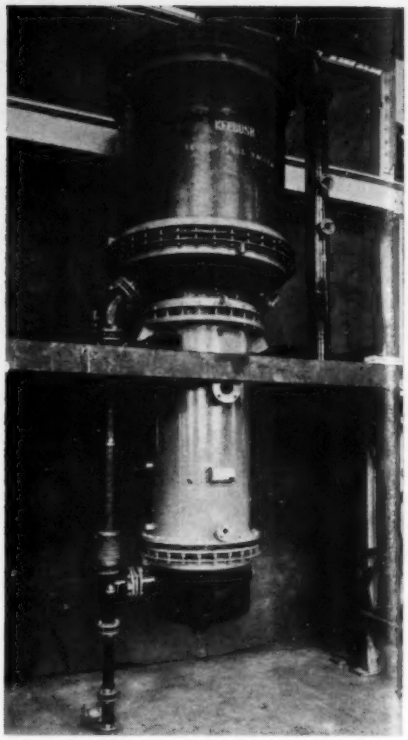


Fig. 6. Kestner climbing-film unit with carbon tubes and 'Keebush' separator.

New equipment

A new form of evaporator in which thin films are employed has been developed by Luwa S.A., of Zurich. These units, as illustrated in Fig. 5, consist of a vertical tube *A*, the lower portion of which is surrounded by a jacket *B* which contains the heating medium. The upper part of the tube *A* is not jacketed and acts as a separator. A rotor *D* driven by an external motor has blades which extend nearly to the bottom of the tube and have only a small clearance between the tip and the jacket. The liquor to be concentrated enters at *A* and is picked up by the rotating blades and thrown against the wall of the tube. This action provides a thin film of liquid and sufficient agitation to prevent local overheating. The film flows down by gravity, becoming concentrated as it falls. The concentrated liquor is run off from the bottom through a pump and the vapour leaves at the top of the unit, where it is passed either to a barometric condenser or to a surface condenser. With this form of equipment the short time of contact of the normal falling-film unit is obtained.

The extending use of carbon and plastics as materials of construction is illustrated in Fig. 6 where a climbing-film unit is shown for concentrating spinning-bath liquors. The tubes are of carbon and are 6ft. long, and the separator is of *Keebush* plastic.

The interesting carbon tube unit manu-

(*Concluded on page 222*)

Demineralisation of Salt Waters

2. POTENTIAL ENERGY SOURCES

In our March issue we published the first part of this article on salt water demineralisation in which separation processes and phenomena were listed and discussed. In this second part, energy sources which might be utilised for demineralisation are described. The information has been released by the Saline Water Programme Administration of the U.S. Department of the Interior.

I. Combustion of fuels

COMBUSTION of conventional fuels needs no discussion here. There have been suggestions that by burning natural and other combustible gases, including hydrogen itself, under water in a demineralisation process, scaling and losses at heat transfer surfaces would be eliminated. In areas where natural gas occurs in abundance, a process of this nature might prove to be practicable. Underground combustion of coal has been suggested as a means of obtaining inexpensive heat for demineralisation and further study of this potentiality for this specific purpose appears desirable.

II. Natural hydraulic potential (falling water)

This energy source is listed in the interest of completeness. Discussion here of hydroelectric power is unnecessary and its development is not a part of the demineralisation programme. Pertinent, however, is the fact that, as with many new industrial processes, some of the most promising demineralisation methods lie in the field of electrochemistry. Such processes would require large blocks of electrical energy, and the cost of a unit of the fresh water produced would depend, to a great extent, upon the unit cost of the electric power. As with the use of solar energy for demineralisation where reservoirs or other facilities may be available for storing the demineralised water, intermittent energy—in this case secondary power at lower cost—could be used.

III. Utilisation of waste heat

The total quantity of waste heat from industrial processes has not been accurately estimated, but is known to be very high. One of the most obvious, and possibly most useful, of such sources is the unused heat from steam- and diesel-powered electric generating plants. Overall efficiencies of such plants are very low-heat efficiencies alone, seldom rising above 33%. Although this energy source is obviously limited, where a portion of the electric power can be used for compressors and the waste heat used for stage evaporation, total economies exceeding any so far suggested might be achieved. Considerable research and small pilot-size development in this area appears in order, as well as a survey of quantities and location of waste heat throughout the United States and elsewhere.

It is well known that the coolant (water) from nuclear reactors contains unused heat. However, the temperatures of the coolant in present reactor plants is low and probably cannot be used economically for other purposes. If reactors are developed which employ coolants at much higher temperatures, it would appear possible to use this heat for direct evaporation, or for generation of electrical energy which in turn might be applied to demineralisation processes.

IV. Nuclear fission

At present the cost of power from nuclear fission exceeds that which can be considered to be economically feasible for use in demineralisation.

V. Solar energy

Solar energy might be used for demineralisation in three or more ways. Evaporation is the most obvious and probably the simplest use. Solar distillers might be classified in two groups; those which receive solar energy directly and those which utilise focussing devices. From the best information available, single-stage evaporation only has been practised. Possible techniques suggested, so far, include evaporation in the solar energy collector itself or in a distilling unit heated by air or other fluid which has previously been heated in the solar collector. Since there is no energy cost, the cost of the water produced by solar evaporators depends almost entirely upon the capital cost and maintenance. For present systems, the investment has been estimated to require a maximum of $1/sq.ft. of area. In a region having the latitude and the normal sunshine equal to that of southern Arizona, it has been estimated that solar energy is available for evaporating 50 gal. of water per year under 1 sq. ft. of exposure, or a cost of perhaps $3/1,000 gal. It may also be practical to obtain power from the steam before condensation and, if so, to reduce the water cost by marketing the power or by using it in other demineralisation processes. The use of multiple-stage evaporation in which the energy is re-used might be possible to reduce the total cost per gallon of water produced. The need for considerable research and development utilising this principle is indicated.

As mentioned under crystallisation, the use of solar energy in refrigerating processes may offer opportunities for economies in demineralisation by freezing. Considerable research and developmental work has been done on the use of solar energy for space cooling, and it seems reasonable to expect that this energy might be used as the direct heat source for low-temperature refrigeration, employing the principles already developed for certain types of flame-powered refrigeration.

A third application to demineralisation is in the development of solar-powered motors or generators, the power from which could in turn be used for other demineralisation processes. Several solar motors have been proposed, but demonstration of their practicability has not been conclusive.

Owing to the vast quantity of unused solar energy, particularly in areas of the United States and other countries where other fuels and energy sources are not readily available, the development of this source of energy would appear very attractive.

Table 2. Potential energy sources for demineralisation

I. COMBUSTION OF FUELS
(*a*) *Conventional*
(*b*) *Non-conventional*
II. NATURAL HYDRAULIC POTENTIAL (falling water)
III. UTILISATION OF WASTE HEAT
(*a*) *Waste heat from industrial processes*
(*b*) *Waste heat from nuclear fission*
IV. NUCLEAR FISSION
V. SOLAR ENERGY
VI. MARINE ENERGY
(*a*) *Thermal*
(*b*) *Wave*
(*c*) *Tidal*
(*d*) *Electromotive force*
VII. WIND POWER
VIII. CHEMICAL ENERGY
IX. ATMOSPHERIC HEAT
X. GEOTHERMAL ENERGY

VI. Marine energy

(a) Thermal energy. Various means of converting the thermal energy of oceans, lagoons, lakes and reservoirs to usable work have been considered for many years. The most frequently suggested technique involves use of temperature differences as discussed under I (*a*), 9, of Table 1 (Part 1). The effectiveness of a marine thermal energy plant using temperature differences would depend largely upon the magnitude of that difference. At a location on the west coast of Africa where a plant of this type is under construction this difference

amounts to some 28°C. For economy of installation and operation it is essential that the source of cold water be near that of the warm water. Where the oceanography is favourable, plants of this type might be economically feasible, particularly since it appears possible that some marketable electrical energy, surplus to the needs of the system itself, might be generated. Some research is under way. For practicability it would be necessary that the temperature differences persist through the year. This fact excludes the use of this process in the northern zones, and probably in temperate zones, where winter conditions would require shutdowns. It appears more feasible for southern and tropical waters.

(b) **Wave energy.** Utilisation of the energy of the seas which manifests itself in waves along the shores has received attention of many inventors and a few scientists. Experimental plants have been installed on piers extending into the ocean, from which small quantities of electrical energy have been generated. Some have suggested utilising the pressures built up by wave action in natural caverns, or constructed compartments, opening on to the seashore where air would be alternately compressed and exhausted. Although practical success has not been achieved so far in the utilisation of this source of perpetual energy, ingenuity and resourcefulness may develop practical processes which alone, or combined with other energy sources such as solar energy, might provide feasible demineralisation processes.

(c) **Tidal energy.** Development of the energy present in tides, especially where the range of the tide is great, as along the north-eastern coast of North America, has been investigated for many years. The potentialities and limitations are fairly well established.

(d) **Electromotive force.** A potential electromotive force exists between any two bodies of water which have different degrees of salinity. Where rivers enter the sea (and at such locations fresh water is usually not in short supply) this electromotive potential is considerable. Elsewhere, however, lesser salinity differentials exist which might be utilised for demineralisation, either directly or by generation of electric power which in turn could be applied to this use.

VII. Wind power

Although wind power as such is not a foreseeable energy source for large-scale demineralisation, and its development is not a part of the current demineralisation programme, it appears possible that small wind generators might be used to advantage in connection with demineralisation units for individual farm needs in areas where the salinity of the ground water only slightly exceeds the maximum allowable for human consumption, livestock or even small-scale irrigation to supplement other farming operations.

VIII. Chemical energy

This energy source is included here in accordance with the concept that all chemical reactions are manifestions of energy, and in recognition of the principle that separation economies fundamentally involve problems in energy conservation. Except as chemical energy enters into combustion, galvanic cells, etc., it is not intended to suggest that this energy be considered *as a power source* in connection with demineralisation. Discussions of chemical separation processes and phenomena indicate the present apparent potentialities of chemical energy as chemical reactions for this purpose.

IX. Atmospheric heat

It has been suggested that the heat contained in the atmosphere might be converted to work for use in demineralisation. That this can be done by use of heat pumps is well known, but means of accomplishing the conversion economically are not apparent. However, since the conversion involves only the movement of heat and not its generation, it would appear that there may be some physical possibility of accomplishing the cycle with a much lower expenditure of external energy than by the conventional principles utilised in the heat pump. Some basic and applied research would appear to be justified.

X. Geothermal energy

A source of almost unlimited energy is the heat of the interior of the earth itself. Visible manifestations of this heat occur as volcanic action at high temperatures, and as springs of hot water and of steam. The heat in certain mines, where masses of rock have been cooling for thousands of years, even now causes temperatures above those in which man can work. In oil explorations at depths of nearly 20,000 ft. temperatures exceeding the maximum for which logging machinery is insulated have been encountered, and it is well known that the heat of the earth increases with depth at a fairly uniform rate in any locality.

Contributions and Correspondence

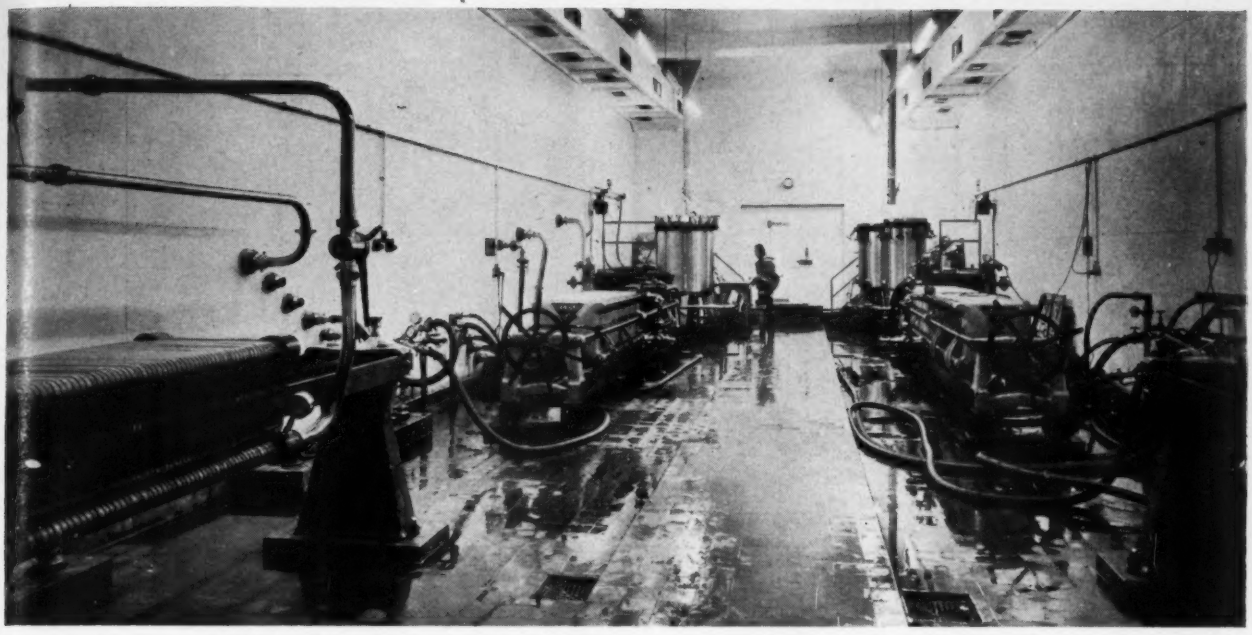
THE EDITOR *welcomes practical articles and notes on chemical engineering and industrial chemical subjects with a view to publication. All contributions, which should be fully illustrated whenever possible, are carefully considered. A preliminary letter or synopsis is advisable. Address such material to* THE EDITOR, CHEMICAL & PROCESS ENGINEERING, Stratford House, 9 Eden Street, London, N.W.1.

Letters for publication on any of the subjects covered by this Journal are also invited.

This tremendous source of energy has scarcely been tapped, although springs of hot water and steam fumaroles have been used for various purposes. In Iceland, the city of Reykjavik receives most of its heat for houses and public buildings from hot springs. In Boise, Idaho, this energy is used for space heating. In the Larderello district of Tuscany, in Italy, geothermic steam generating plants have been constructed with a total capacity of more than 125,000 kw., and in New Zealand explorations are now under way to open and develop great subterranean steam beds to meet the growing demand for electric power.

In all of these present uses steam or hot water already present in the earth is put to use and, if it were necessary to confine the utilisation of geothermal energy to areas where such subterranean water or steam already exist, use of that resource would be quite limited. However, it has been suggested that, since the heat of the earth is known to increase as greater depths are reached, it might be possible to construct borings or shafts into which water or some other liquid heat transfer medium could be introduced, and returned to the surface at high temperature for use as a heat source for any purpose. That it would be physically possible to make use of this energy there is no doubt, nor is there doubt that the use could include distillation of saline water and concurrent generation of marketable electric power. Problems involved are largely economic and investigations would include such determinations as: locations of areas in which the geothermal gradient is high near sources of saline water; determination of heat conductivity of the rocks in those areas; development of methods for constructing large capacity wells or shafts in rock of high temperature. Any water or other liquid used as the heat transfer medium should be such that deposits, scale and corrosion within the underground system would be negligible. The saline water could be distilled with this energy only if actual distillation took place at the surface, and if distilled water or other non-scaling transfer medium were used in the subterranean system.

This source of energy need not be confined to distillation processes. In areas where the geothermal gradient is high, *i.e.* where hot beds lie close to the ground surface, it appears possible that this source of energy might be used for the generation of electric power. It involves no consumptive use of water. Some studies and surveys, both in the United States and other lands, would appear to be in order to determine the practicability of utilising this energy source for (*a*) demineralisation and (*b*) other purposes. The outstanding potentiality in its use for demineralisation lies in the possibility that a marketable by-product—electrical energy—might be produced, which would defray the cost of the water.



The new filter room at Ind Coope's Burton brewery. In the foreground are the Paraflow chillers and, in the centre, two double Carlson sheet filters. The Bowser diatomaceous earth filters are in the background. Cold air from the ducting shafts above passes through the room to maintain the temperature at freezing point.

Reconstruction of a Beer Conditioning and Cooling Plant

By A. G. Thomson

To meet the growing demand for bottled beer, Ind Coope & Allsopp Ltd. are redesigning and rebuilding their extensive bottling facilities. A fully mechanised bottling store capable of handling a million bottles per two-shift day has been built at Burton-on-Trent. The cold room capacity has been enlarged and the refrigeration plant for the entire brewery has been centralised in one building. The processes of conditioning, chilling and filtration in the reconstructed facilities are described by our contributor, who also explains the new cold-room layout.

THERE are two alternative methods of treating beer before bottling. The first and older method is to allow the beer to mature in cask for several months before bottling. The other method, used by Ind Coope & Allsopp, is to mature or condition the beer in tanks, followed by a chilling and filtering process. In the conditioning tanks the beer is agitated by motor-driven propellers and a secondary fermentation takes place. In this way, a clean drinking beer is produced, while a pressure of carbon dioxide gas is developed. Both are important factors in the production of high-quality bottled beer.

From the conditioning tanks the beer is transferred to a chilling plant which reduces the temperature to about 32°F. The primary reason for chilling is to induce artificially precipitation of substances which would produce hazes at a later stage, when the beer is in bottle. The beer remains in the cold store for at least two weeks, during which time a natural clarifying action takes place. The product is then subjected to two stages of filtration, after which it is ready for bottling.

The existing conditioning and chilling plant was laid down many years ago and extra plant was added as the bottled beer trade increased, so that the original installation was swamped. Eventually it was decided that no good purpose would be served by enlarging it any further in its existing form. In the conditioning rooms the primary requirement was a new layout which would allow the capacity to be increased and a more efficient system to be produced. The alterations had to be carried out without excessive dislocation of production, and this involved taking out perhaps ten tanks at a time, resurfacing the floor, and afterwards installing new tanks in the prepared positions. The effect has been to transform a mass of irregularly placed tanks into a series of orderly rows, and at the same time to increase their number by 25%. While the conditioning room was being modernised a new filter room and a new cold storage room were constructed.

Conditioning

Each conditioning tank is now mounted on adjustable legs so that it can be made dead level, the height above floor level being adequate for cleaning purposes. Beer is delivered by centrifugal pumps from the floor below. No tank is filled until it has been thoroughly cleaned inside and has been passed by an inspector. To prevent the formation of excessive fob, filling is started against a back pressure of about 5 p.s.i. and as the beer goes into the tank the displaced air is gradually snifted off. By the time the tank is full the pressure has come right back to zero, but with fermentation it then starts building up again and eventually reaches 30 p.s.i., at which level it is held by snifting

off the carbon dioxide gas as required. During this secondary fermentation the temperature gradually rises.

The older tanks have two cocks, one on the side for filling and the other on the bottom for emptying; coupled to the bottom cock is a thimble by means of which the settled yeast is left behind in the tank when the beer is drawn off. The latest tanks have only a single cock for both filling and emptying. All tanks are of glass-lined steel, and the room is maintained at about 65°F. by circulation of air over steam radiators.

Chilling

The conditioned beer used to be passed through a counter-current chiller in which it flowed through a centre tube surrounded by brine as the cooling agent. In the new filter room this has been replaced by very modern plate chillers of 120 barrels/hr. capacity, in which the chilled brine passes through one side of a plate while the beer passes on the other side, so that the heat is transferred from the beer to the cooling agent through the plate. Having been chilled down to 32°F., the beer is stored at that temperature in an air-cooled room, but it still has to be filtered. It is therefore transferred after a suitable interval to the filtration room.

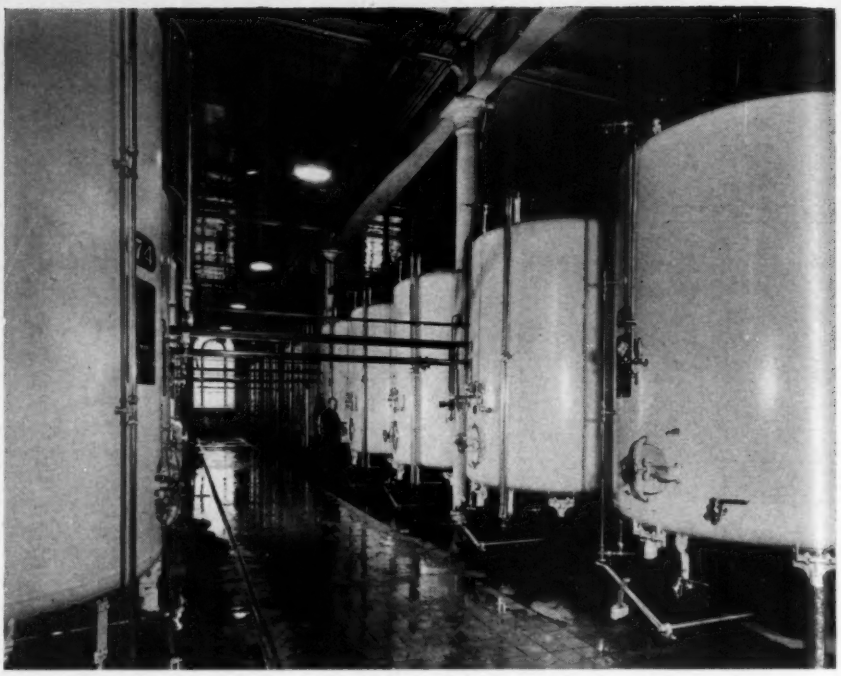
Filtration

The effect of chilling is to precipitate the haze-forming substances, which are then removed in two stages of filtration. The first filter, which removes the larger particles, is known as a 'rougher.' This consists of a filter tank containing fine stainless-steel wire-mesh screens through which the beer must pass. As the beer is fed into the filter a diatomaceous earth powder of suitable grade is injected as the filter medium. This is held back by the wire screens, and gradually builds up into a filter bed, in which all the particles suspended in the beer are removed. These filter powders are graded according to the size of the particles of which they are composed, the grade used varying according to the type of beer to be filtered. The powder, of course, is chemically inert to the beer.

'Polishing'

The beer is then passed through a polishing filter, from which it emerges perfectly brilliant. This filter consists of enamelled plates between which are placed filter sheets of cellulose and asbestos fibres. These sheets are periodically cleaned by counter-flowing water, which takes off the deposit and carries it to waste. When back-washing ceases to be effective, the sheets are renewed. These sheets are also used in different grades according to the type of beer and the degree of filtration required. Sheets of sufficient fineness to give completely sterile beer are used in certain conditions.

When filtration is completed, the beer is ready for transfer to the road tankers, which transport it to the various bottling stores. The tankers are of stainless steel, lagged to insulate the beer from temperature changes during transit. As with all the other tanks in this plant, these containers are thoroughly cleaned on return to the brewery and must be passed by inspection before re-filling.



The conditioning room. Beer for bottling is conditioned in 128 glass-lined, 60-barrel tanks, some of which are shown.

Cold room layout

One cold room is equipped with two dozen 120-barrel tanks which are arranged in two rows, one above the other. An overhead gallery gives access to the upper row. This room has been designed on a new principle, which consists of 'cabinetising' the tanks so that they are completely separated from the working passage and thus can be subjected to maximum cooling without rendering working conditions too unpleasant for the operators, who remain in the passage at a slightly higher temperature. This system has enabled the temperature of the beer to be controlled much more delicately than was previously possible. Another advantage is improved cleanliness, due to the fact that all outlets from the tanks are into the working passage and no beer can get under the actual tanks. Formerly there was a space between the floor and the bottom of the tank, which presented a very difficult cleaning problem. The colour scheme of the cold room consists of white walls and roof, grey steelwork and red tiled floors.

Present programme

The present programme envisages the reconstruction of three separate chilling and cold storage rooms. The first plant is in full operation and work has been started on the second. Should the swing-over from draught to bottled beers continue at the present rate, it may be necessary to provide for a further increase in cold room capacity when the present programme has been completed. This could only be achieved by laying down an entirely new unit, as it is considered that a plant larger than the one at present planned would become unmanageable.

Refrigeration plant

Formerly there were five separate compressor houses each situated close to the department which it served. The refrigeration capacity of the brewery has been increased and the whole of the compressor plant has been centralised in a new building erected on a site which adjoins the conditioning and cold rooms. The plant includes both electric and diesel-driven units, the former being used at night and the latter during the day. By using two different forms of power the risk of a breakdown which might interfere with the cooling processes has been minimised. The advantage of including electrically-driven units in the compressor plant is less noise at night, while the use of the diesels during the day reduces the load at peak periods. Brine is circulated by 22 pumps of varying capacity and is piped to and from the cold rooms over three bridges, one of which will eventually carry 27 pipes. If a pump normally serving any particular cold room should fail, its place can immediately be taken by another unit. The entire system of brine distribution is automatically controlled.

GAS ENGINEERING IN THE U.S.A.

The latest Productivity Report* by a British team deals with the American gas industry and it pinpoints the sharp contrast between the industries there and in Britain. The major difference is the widespread use of natural gas in America. In spite of these differences the team found many aspects of American practice which could be used in the British industry to advantage. Below we publish extracts from the report dealing with gas production, purification and by-product manufacture.

Gas production

IN comparing the processes of gas manufacture in the United States and the United Kingdom it is essential, the report says, to appreciate that, following the greatly developed use of natural gas, the manufacture of gas from coal, coke and oil in the American gas industry has declined, and now contributes about 5% of the total gas sales. In the U.K., 99.7% of the total gas sold is manufactured gas.

The comparison is most marked in the production of gas by the carbonisation of coal, and the team had to go outside the gas industry to get some of the information it sought on carbonisation.

The American gas industry produces only 330 million therms of coal gas, or 0.7% of the total therms sold, whilst in Britain the gas industry produces 2,000 million therms of coal gas, equivalent to 74% of the therms sold. Furthermore, in the U.S. the coal is carbonised almost entirely in coke ovens, while in Britain only a small proportion of the coal used by the gas industry is so carbonised.

Although in American carbonising practice coke for industrial purposes is regarded as the primary product, and not gas as in Britain, several features emerge of interest to our own gas industry. First, in order to ensure optimum efficiency of operation of ovens, the Americans select carefully the coals they use and confine their selection to a very small range. The same facility for selection is not available in this country, but it is urged that 'despite the limitations in supplies and geographical difficulties, greater effort might be made to obtain more selective allocation of coal within the industry and to individual plants.' Secondly, the operational life of ovens is generally long, and it is felt that the high quality of American silica refractory material is worthy of further investigation as a contributory factor in this long life of ovens. Otherwise there is no evidence to suggest that the operation of modern carbonising units in this country is not at least as efficient as in America.

Carburetted water gas is made in quantity in this country as a supplement to coal gas; it was used to an even greater extent in America prior to the receipt of natural gas, but relatively little is made now. Valuable technical information was acquired concerning the intensive efforts that were then made to obtain maximum outputs from carburetted water-gas plants and the use of the cheaper heavy fuel oils.

Owing to its importance, this matter has been dealt with in great detail in the report, and information gathered at first hand is given of plant operations.

The modern American practice of gasifying oil to produce gas of 1,000 B.Th.U. quality has not been adopted in this country and is not applicable except in special cases. Again, however, considerable information was obtained from American research and practice as to the selection and use of heavy oils for gasification.

Liquefied petroleum gases (propane and butane) are now becoming available from the expanding oil refineries of this country, and their use by the gas industry in Britain, based upon American experience, 'presents potentialities, subject to satisfactory terms of purchase and to long-term security of supplies.' The report indicates the direction in which developments are foreseen, and affirms that they can provide a useful contribution to coal economy. It is desirable as a necessary part of such developments that suitable plant, equipment and transport be made available by manufacturers in Britain, and that a standard code of practice be prepared covering design, installation and plant operation, with special regard to fire and explosion hazards during transport and in storage plants.

Processes associated with the purification of gases and the production of by-products are dealt with under two main sub-headings, the physical and the chemical.

PHYSICAL PROCESSES

Condensing

The condensing process, as applied to coal gas, does not appear to have received more detailed attention in the U.S. than in Britain. In the six coke oven plants visited there appeared to be ample capacity available to reduce the gas to a temperature suitable for the semi-direct recovery of ammonia.

Two chief methods were in use, that of 'direct' coolers in which the gas and cooling water were in direct contact, and the conventional type of water-tube condenser.

The processes for treating the ammoniacal liquor, tar, naphthalene and, in some instances, emulsions emerging from the condensing plant are dealt with later.

Detarring

In general the procedure in the plants visited was to place the electrostatic detarrers immediately after the exhausters, although the operating voltage varied widely from 15,000 to 60,000 volts d.c.

In several plants serious corrosion of the electrodes had been experienced and was attributed to ammonium chloride. This was claimed in one large plant operating on coke oven gas to have been eliminated by spraying hot tar at a temperature of 80°C. for 10 min. once a day on to the underside of the top tube plate.

Although electrostatic detarring is practised widely, there appears to be a lack of safety regulations, particularly those concerning interlocking gear. It was observed, however, that on one plant an oxygen recorder was installed and so arranged as to trip the electrical circuit when the oxygen content of the gas reached 2% by volume. In another works inert gas is used for purging the plant before opening, and also prior to putting into commission.

Naphthalene removal

Apart from the usual washing processes in connection with benzole recovery and the removal of 'gum-forming' compounds, several instances were observed where naphthalene was removed from the gas by direct shock-cooling with water. The naphthalene was skimmed from the surface of the water, melted and sold in the crude state. In one very large coke oven plant the gas leaving the ammonia saturators passed to a cooler system and the naphthalene was absorbed in tar and passed to the tar storage.

Gum prevention

No gum problems of any considerable magnitude were met with. So far as coke oven gas was concerned, help was obtained from the exhausters, which were practically all of the high-speed turbo type and assisted in the removal of both gum-forming hydrocarbons and of gum already formed. In general, oil-washing is also relied upon to remove gum-forming compounds. With natural gas the problem does not exist.

At one works an interesting method of nitric oxide removal from 24 million cu. ft. of coke oven gas a day has been in opera-

*Copies of the report (price 8s. 6d., post free excluding air mail) are obtainable from the British Productivity Council, 21 Tothill Street, Westminster, S.W.1, and from the Gas Council, Gas Industry House, 1 Grosvenor Place, London, S.W.1.

tion since 1935. The gas is subjected to a brush discharge, and the nitric oxide is converted to higher oxides and subsequently removed by the wash oil. The efficiency of nitric oxide removal is about 98% and the cost is low. Descriptions of the plant have been published.*

Benzole recovery

The direct recovery of benzole from gas by solid absorbents was not met with in the U.S.

The washing of coke oven gas with oil, usually a petroleum fraction, follows normal practice, but the amount of wash oil employed varied widely, from 3,000 to 15,000 gal./million cu. ft., while the procedure for dealing with the product obtained by 'stripping' the wash oil was far from uniform. In some instances the light oils were sold in the crude state, while in others a rectifying column was used and various 'cuts' were made. At one plant the fore-runnings from the column are heated in a vessel for 6 hr. at 145°C. in order to polymerise the cyclopentadiene to the dimer, which is then recovered and sold to resin manufacturers. The procedure for washing oil gas is similar to that for coke oven gas.

Gas drying

Gas drying applied to manufactured gas as practised in Britain was not seen in the U.S.; on the contrary, several instances were met with where the gas was humidified with steam—about 800 lb./million cu. ft. being used—because of rust and dust from the distribution systems consequent upon the introduction of natural gas.

Sometimes oil is also atomised into the gas in an endeavour to protect consumers' meters.

CHEMICAL PROCESSES

Removal of ammonia

In all the coke oven plants visited the recovery of ammonia is by the semi-direct process and in a number it was associated with dephenolation and the partial recovery of crude tar bases, so that the whole process is closely associated with the problem of effluent disposal. The general consensus of opinion appeared to be that by-product ammonia recovery was not of itself a paying proposition although requirements in connection with effluent purity introduced a new factor in its favour.

The same observations apply to dephenolation and pyridine recovery. Probably one reason why the economics of sulphate of ammonia production varied so much was that a number of the plants had been written off, while in others new and costly equipment added considerably to the charges. Five large plants manufacturing sulphate were inspected.

*'The Koppers Electrical Process for the Prevention of Nitrogenous Gum in Distributed Gas.' W. I. Shiveley and E. V. Harlow. A.G.A. 1936.

Dephenolation

At two plants visited dephenolation was practised after the removal of the free ammonia from the liquor. The phenolic bodies are removed by a counter-current of steam, and the phenol-laden steam is washed by 5% aqueous caustic soda, and the resulting sodium phenate solution, after being concentrated to give a tar acid content of 18%, is sold to chemical manufacturers. In one plant it was stated that the cost of labour, caustic soda and steam just about balanced the receipts from the tar acid solution, the plant having been written off, while in the other the dephenolating process was worked at a loss the magnitude of which was not given.

Recovery of crude tar bases

Of particular interest were the small compact plants installed for the partial recovery of crude pyridine or tar bases from the mother liquor of the sulphate of ammonia saturators, but the economic position of the process appears to be doubtful. Five plants were inspected, some of which were of lead-lined construction and others of stainless steel, and in all the crude bases were sold as such, having a water content of about 20%. The bases were liberated from the sulphate by a stream of vapour obtained from the free section of the ammonia stills. In one plant the operating costs were stated to balance the receipts, while others claimed variable profits on the recovery process.

Removal of hydrogen sulphide

The chief differences between procedure in the U.S. and Britain are due to three main factors:

(*a*) The standard requirements for purity;
(*b*) The relatively small amount of manufactured gas distributed in the U.S.;
(*c*) The absence of ready supplies of indigenous sulphur in Britain.

For purity of gas, the standard in Britain requires a freedom from hydrogen sulphide which is of the order of 1.5 p.p.m. by volume, or about 0.09 gr./100 cu. ft., while no restriction is placed on organic sulphur compounds. In the U.S. there are various State regulations which generally specify the permitted amount of total sulphur and so permit a greater freedom with respect to hydrogen sulphide. It should also be noted that in Britain the purification processes have to deal with a hydrogen sulphide content three or four times as great as in the gases dealt with in the U.S. where they are mainly derived from oil or natural gas which in itself, except in special circumstances, does not present a sulphur problem.

All the plants inspected using liquid purification methods were worked so as to remove about 90% of the hydrogen sulphide from the gas, while conventional oxide purifiers completed the process. Only in two was the sulphur actually recovered, so that manufactured gas purification in the U.S. does not, at the present time, contribute to the solution of the sulphur shortage.

In one plant 25 million cu.ft./day of oil gas containing 350 gr./100 cu. ft. of hydrogen sulphide is purified down to a content of 50 gr. by the *Thylox* process. As is well known, this process employs an arsenic compound, and details have been published in the technical Press, particularly by Koppers. The sulphur produced is washed and filter-pressed, but it was emphasised that when working on oil gas it is not possible to produce sulphur of fine quality because of the difficulty of removing traces of oily matter.

The sulphur paste recovered in this plant contains about 96% sulphur on the dry basis, and is sold with a water content of 50%. It finds a ready market for the manufacture of insecticides. It was noted that the plant requires about 24 hr. to attain satisfactory operating conditions after a shut-down.

The other plants visited were using either the Koppers ordinary *Seaboard* process or the hot activation vacuum process. As an example of the first, the gas from the ammonia saturators, free from ammonia but containing hydrogen sulphide, hydrogen cyanide and benzole, passes to the liquid purification plant, where about 90% of the hydrogen sulphide and all the hydrogen cyanide are removed.

The gas is washed under a pressure of about 30 in. w.g. in a 60-ft. mild-steel tower packed with three tiers of wooden grids each 10-ft. high. The wash liquid is 2.5% aqueous sodium carbonate circulated at a rate of 800 gal. ton of coal. In this works a low-sulphur coal—0.7% total sulphur 'as charged'—is carbonised, and the crude gas contains only 250 gr. of hydrogen sulphide, which is reduced by the process to 30 gr., and at the same time the carbon dioxide content of the gas is reduced from 2.5% volume to 1.5%.

After this operation, the wash liquor is pumped to an activator tower and a stream of air approximately twice the volume of gas treated is drawn through it by a fan. The resulting foul air, containing 100 to 120 gr. of hydrogen sulphide, is burned under Stirling boilers or gas producers so that the sulphur dioxide reaches the atmosphere *via* the various stacks. There has been considerable trouble in the boiler house chimney, and an annular lining of special glazed tiles had to be inserted at considerable expense to the full height of 307 ft. The steel tracks under the chain-grate stokers had to be renewed after two years. The soda ash make-up was given as 0.07 lb./1,000 cu. ft. of gas treated.

The Koppers vacuum carbonate process for hydrogen sulphide removal was of special interest among the plants visited. In this plant the crude gas contained 320 gr. of hydrogen sulphide and about 85 gr. of hydrogen cyanide per 100 cu. ft.

It is of interest to note that the hot

vacuum carbonate process is to be installed at a works in this country.

Sulphuric acid plant

Apart from the *Thylox* plant already mentioned, the acid plant working in conjunction with the Koppers vacuum carbonate process was the only example of the recovery of sulphur in a useful form. It is of the contact type using a vanadium catalyst, and has a capacity of 60 tons/day of 100% sulphuric acid. The plant can operate on both elemental sulphur and the hydrogen sulphide provided by the vacuum purification plant.

Hydrogen cyanide plant

This very interesting plant, which was inspected in detail, is described fully in 'Cyanides from the Coke Oven,' by Kastens and Barraclough.* Briefly, the mixed gases from the vacuum purification plant consist essentially of hydrogen sulphide 65%, hydrogen cyanide 20% and carbon dioxide 15%, all saturated. The hydrogen sulphide and carbon dioxide are driven off and the hydrogen cyanide is absorbed selectively in water in a stainless-steel tower packed with unglazed porcelain saddles. The HCN is stripped from the aqueous solution by steam and condensed at −5°C. and atmospheric pressure, being then stored in stainless-steel tanks. The liquid HCN, 99.6% pure, is stabilised by 0.01% orthophosphoric acid to prevent polymerisation, and is ultimately converted to sodium or potassium cyanide by releasing the liquid into the appropriate hydroxide. Most of the plant equipment is of stainless steel and extreme precautions for safety and the training of operatives are in force. There is auto equipment for warning of polymerisation, and for *p*H control. There are no gas lines at the rear of the instrument panels, all control being remote. All motors, wiring and lighting equipment are of approved explosion-proof type. The refrigeration plant used *Freon*, not ammonia, and only one replacement charge has been required in two years, and that was due to contamination with oil.

Experiments on the hydrolysis and ultimate destruction of hydrogen cyanide have been successfully carried out on behalf of the Woodall-Duckham Co., of U.K., in a pilot plant of about one-tenth the capacity of the main plant.

Oxide purifiers

The removal of hydrogen sulphide by oxide of iron in conventional purifiers was examined at nine plants and, with coal gas, was applied either to complete purification or to the completion of the process, after the removal of up to 90% of the hydrogen sulphide by liquid purification processes. With oil gas the oxide purifiers, with one exception, were used for the complete purification. The chief points which emerge from a consideration of these plants are:

(*a*) All except one were situated in the open, usually at ground level. Dry lutes and various methods of up, down and split stream flow were used. Many of the boxes were of mild-steel welded construction, and rectangular, although some circular purifiers with tall, narrow side discharge doors were seen.

(*b*) They were generally emptied manually with the aid of mechanical picks and shovels, sometimes assisted by grabs.

(*c*) Air for revivification *in situ* was usually added and no particular attempts were made to work the oxide up to a high sulphur content.

(*d*) There were no specifications for the purifying material and, while much lux mass opened up with softwood shavings was used, other materials included local limonite, or even rusted iron borings.

(*e*) In all instances coming within our notice the spent oxide was dumped.

Sulphur problem

The removal of organic sulphur compounds from gas was not receiving any more than academic consideration in the U.S., for the obvious reason that it does not constitute a problem of any magnitude because such coal gas as is distributed is sufficiently diluted by other relatively sulphur-free gases.

Effluent treatment and disposal

Both countries appear to be actively engaged on methods for the improvement of effluents, to the ultimate benefit of the condition of rivers. This is due partially to the pressure of recent legislation, but it must be emphasised that the various processes involved, such as dephenolation of liquor, would appear to be a charge upon the gas-making process, and thus the improvement in the state of rivers, which is admittedly desirable, will have to be paid for indirectly.

The problem may be of even greater magnitude in Britain, because the preponderance of manufactured gas results in a much greater volume of effluent, while the smaller rivers considerably reduce facilities for dilution and disposal.

The methods of effluent treatment and disposal met with in the U.S. vary considerably, as do methods of disposing of the effluent water. In one large works the effluent is filtered by seepage from a private pond and percolates into the river which, however, is already polluted from paper mills and sewage. The company proposes to experiment with amine treatment and the use of a closed system, but it is anticipated that such a procedure will be costly.

Another company, though it has never been called upon to take any action on effluent, has during the past year embarked upon a programme of river and atmospheric pollution research and, in that connection, it is argued that the Koppers vacuum carbonate process for hydrogen sulphide removal represents a considerable contribution to the effluent problem, because practically no effluent is produced by it.

As in Britain, the various harbour authorities are taking an increased interest in effluent disposal, so that liquids containing various constituents may, in the future, have to receive special treatment before discharge.

At present there are no official specifications for effluents in the States, but the matter is receiving the close legal attention of the various authorities concerned.

It is not known whether any work is in progress in the States on the decolorising of effluents, but some work has been done on the use of ozone for reducing the oxygen absorption of effluents, and the Standard Oil Co. has made a grant to Ohio State University for an investigation into the use of biological attack to combat stream pollution by industrial wastes.

The still effluent from one large coke oven plant amounts to 170,000 gal./day and flows direct to a river, but in the near future it is proposed to pump a large proportion of it to the coke quenching plant. The crude liquor, which contains 2,500 to 3,000 p.p.m. of tar acids, is dephenolated and the effluent liquor contains on the average, say, 100 to 150 p.p.m. The River Commission is proposing to require the phenol content of the river to be not more than 3 parts per 1,000 million on account of chlorination problems.

In another instance the authorities stipulate that the effluent shall be satisfactory for acceptance into the city sewers and for treatment by their activated sludge process. Only ammonia still effluent passes to the sewers at a rate of about 78,000 gal./day, and at a temperature of 194°F. While this temperature is high judged by British standards, it has to be remembered that there is a very large flow in the 18-ft. diameter sewer. Payment for acceptance of the effluent is made on the basis of 24 cents per 1,000 cu. ft. (equivalent, say, to 3½d. per 1,000 gal.); the effluent is measured and recorded at the gas works. This arrangement has been in operation since January 1, 1952, so that few details are yet available.

One interesting plant inspected dealt with coke dust removal from producer gas washer-cooler water. This effluent was a nuisance because of the gritty suspended solids present, and two concrete tanks were constructed to give a settling time of 50 min. at a maximum flow of 2 million gal./day. The silt is removed from the tanks by a drag bar conveyor moving at 2 ft./min., which operates for 1 hr. and is then shut down for 2 hr. At present the silt is accumulated in a dump, but a conveyor is under construction to carry it to rail cars. It drains down to a moisture content of 30% after the drag bar conveyor, and is mixed with coal fed to the coke ovens.

No costs of the process are yet available.

*Ind. and Eng. Chem., 1951, **43**, 1882.

Maintenance and Reconditioning of HEAT EXCHANGERS

By G. E. Halter

Careful and regular maintenance is essential to keep heat exchange equipment working efficiently. Practical advice on maintenance and reconditioning is given in this article by an experienced plant engineer.* He deals with the main types of equipment in turn, discusses cleaning methods and materials of construction and concludes with a number of valuable hints on the care of the special tools required for heat exchanger maintenance.

THE list of common types of equipment falling within this category contains items varying between small calorifiers and large pipestills. The former may perform work at a rate, say, of 20,000 B.Th.U./hr. The pipestill may work at the staggering rate of 150 million B.Th.U./hr. Between these items are many types of plant, and some of the more common will be mentioned.

Tubular heat exchangers

Equipment, comprising chiefly a shell, containing a relatively large number of small-diameter tubes, is used for such duties as:

(*a*) Heating or cooling liquids either by direct liquid/liquid method or gas vapour/liquid.
(*b*) Condensation of vapour or gases.
(*c*) Vaporisation of liquids.
(*d*) Evaporation.

Jacketed equipment

This type of equipment is usually used for heating liquids up to approximately 212°F. and consists mainly of:

(1) Jacketed tanks and receivers.
(2) Jacketed pans.
(3) Jacketed pipes.
(4) Jacketed chilling units.
(5) Steam driers.
(6) Jacketed pumps.

Shell and tube heat exchangers

There are a number of standard type heat exchangers and the more common will be described together with the various problems associated with the different types.

Fig. 1 illustrates a multi-pass heat exchanger with removable tube bundle. The liquid in the shell of these exchangers can be used in a single- or two-pass method, while in the tube bundle any desired number of passes can be arranged.

The illustration shows a two-pass shell and four-pass bundle combination and is suitable for heating a liquid while at the same time cooling the heating medium. This dual-purpose operation is used extensively in refining and chemical plants.

Care should be taken with the layout to ensure that the exchanger is installed in a manner convenient for subsequent maintenance. For instance, if a hot residual liquid is required to preheat a cold feed stock it would be practice to pass the cold liquid through the jacket and the fouling liquid through the tubes. The reason for this preference is the relative ease with which the inside of the tubes can be cleaned compared with the external cleaning, which, towards the centre of the bundle, can be difficult.

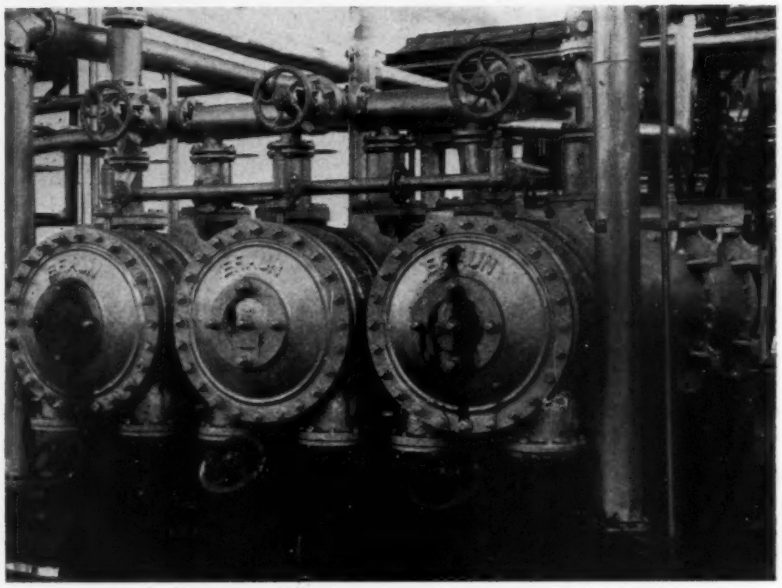


Fig. 1. Multipass heat exchanger with removable tube bundle.

When dealing with two liquids, both of which present fouling difficulties, it is advisable to arrange the tubes to a square pitch.

Where subsequent cleaning is not expected to be a problem a 60° pitch is usually preferred and this arrangement will given an increased surface area of some 25%. The chief maintenance problem with this type of equipment usually occurs at the floating head joint. The jointing material weakens and leakage at the joint follows, due mainly to the alternate expansion and contraction caused by starting and stopping operations. To harden up this joint necessitates removal of the end cover, and in process plants the inconvenience of this can be appreciated.

Designers have adopted various methods to combat this problem, such as the use of metallic joints, spigot and fawcett flanged cover and the fitting of stay bolts equally spaced over the area of the cover. These improvements bring their own problems and it is very important that the material used for a metallic joint ring should be studied to ensure that corrosive action does not occur which will permanently damage the joint faces.

The nuts on stay bolts are a continuous source of trouble and it is important that a crown or blind head nut is used (Fig. 2). The gasket joint for these nuts should be made from thin corrugated rings, and cupro-nickel has proved satisfactory for most purposes.

In special cases, mainly in chemical or treatment plants, where contamination of the two liquids creates corrosive conditions, a somewhat unorthodox method has been found very satisfactory. The end cover is welded (when the materials of construc-

*This paper is reproduced, by permission, from the *Journal of Incorporated Plant Engineers*. It gained the Silver Medal (first prize) of the Alexander Duckham Memorial Awards, 1953.

tion permit) to the tube plate as shown in Fig. 3. Until the bundle requires re-tubing it is not necessary to remove this cover.

Where machine shop facilities are available the removal of the welded cover presents no difficulty, but even without this advantage the weld metal can be flame-gouged with a little practice.

Perhaps the most effective method of dealing with floating head joints for general purpose duties is the use of a high-grade, very thin ($\frac{1}{32}$ in.) compressed asbestos jointing material which is reinforced with wire.

Two at least of the leading jointing manufacturers market such a product primarily for such duties.

A last point concerning this troublesome floating head joint concerns the bolts used to secure the cover. It is essential to use high-tensile bolts of good quality to ensure that no appreciable 'stretch' takes place under the most arduous conditions.

Sooner or later with this type of equipment tube failures will occur and it will be necessary to replace several tubes, or more usually re-tube the complete bundle.

Difficulty is frequently encountered in getting this type of work carried out by local contractors and at any rate it is far more economical to carry out the reconditioning in the workshop.

For the benefit of those who may wish to carry out this operation a brief description of the procedure is attempted.

The methods in general use for securing tubes in the tube plates fall into three categories. Probably the most popular is the expanded or rolling method. Secondly, welded tube ends are finding favour in recent years. Thirdly, the packed gland type are popular for condenser equipment.

Dealing with the expanded tube construction, it is necessary to drill out the tube ends to a depth equal to the thickness of the tube plate less $\frac{1}{8}$ in. A drill size equal to the diameter of the tube is usually satisfactory. It is important that this procedure be followed, as any excess depth beyond the inner surface of the tube plate will probably result in a fracture of the tube, making removal more difficult.

Fig. 2. Crown or blind head nuts for stay bolts.

Two square-end shouldered drifts are required, one short and stiff and the other of suitable length to follow the tube through, say, 2 ft.

After removal of the tubes it will generally be noted that stay bolts hold the spacer baffle plates and that a frame structure remains. The next operation consists of cleaning and preparing holes in tube plates. It is vital to remove material left in the expansion grooves of the main holes and to clean and inspect each hole individually.

The tubes are next prepared, care being taken to check the length, as it is desirable to have uniform tube length.

At this point it should be ascertained whether tubes have been annealed during manufacture. If the specification has not provided for this it is usual to anneal tube ends for 6 in., after which all ends are cleaned to bright metal.

Before assembling the tube bundle it is good practice to test the faces of the tube plates for flatness. Frequently it is found that plate surface is convex, the swelling being due to the initial expanding and the fact that there is a high concentration of the tube at the plate centre. If possible the plates should be machined and it is sometimes arranged that the plate is left with a slightly concave face.

The tube bundle is now assembled, great care being taken that end plates are perpendicular and square to the axis of the bundle. After checking that tube ends project approximately $\frac{1}{16}$ in. beyond the plate face, several tubes are rolled at the top, bottom and both sides. On larger bundles tubes can be rolled at six points of the circumference. The tube should be lightly rolled at first, following which the bundle should be checked for length, squareness and that end plates are parallel. If satisfactory, the tubes are rolled to the desired amount. While the technique of rolling is acquired very quickly it is difficult to prescribe an exact procedure, but for general purposes it will be found that, providing a standard expander and tommy bar are used, if one rolls until the expander can just be moved using, say, two fingers on the bar, a satisfactory expansion will be obtained.

A final check should be made, following which the tubes can now be expanded using a small pneumatic or electric machine if desired, but slow speeds are necessary.

For the lubrication of expanders during rolling, an extreme pressure lubricant can greatly increase the life of rollers and mandril.

While this rolling is satisfactory for all normal requirements, special high-temperature and -pressure work, it is sometimes followed by a flaring tool which, as its name implies, flares out the end projecting beyond the plate surface.

In the case of a multi-pass tube bundle, the end plates must again be checked for flatness and, if distortion has occurred, it is necessary to machine before use. A point should also be made here to check the outside diameter of the small end plate. The initial clearance of these plates in the shell is limited and following re-tubing it will be found that the diameter may increase $\frac{1}{16}$ in. or more, and care should be taken to ensure the new tube bundle will pass freely through the shell.

A hydraulic test to twice the working pressure is usually sufficient, but for equipment used on corrosive duties an air test is desirable.

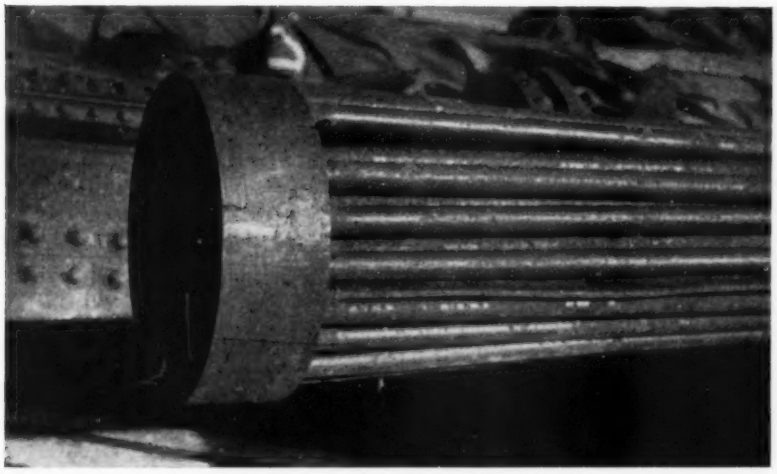


Fig. 3. End cover welded to the tube plate, a method found satisfactory for corrosive conditions.

Shell and tube exchanger with fixed end plates

Where working conditions permit, this type of exchanger is preferable from a maintenance point of view. When re-tubing is necessary little skill is required in setting as the tube plates are fixed.

A source of maintenance trouble in both the removable-type bundle and the fixed-plate exchanger is caused through erosion, owing to impingement at the inlet stool. With the former a thin plate is usually strapped around the tubes at the appropriate place and is quite satisfactory.

With the fixed-plate type a baffle is

usually incorporated in the original shell design and permanently fixed. Should this baffle require renewing, some ingenuity is required and it is advisable that the method to be used is agreed before the new tubes are fitted.

It will be found that, as the baffle is to be made in sections and assembled inside the carcase, the absence of the tubes will greatly facilitate this operation.

A feature of design should be mentioned at this stage. In spite of the known fact that 50% of failures in the shells of this type of exchanger occur at the branch connections, designers and manufacturers still adopt this method with the added precaution of using a heavy wall section branch pipe.

Where conditions are such that these branch pipes do require renewal it is preferable that a studded pad be used. In process plants, where site welding is prohibited, much time and labour saving is possible by this modification. The chief disadvantages of this type of exchanger lie in the difficulty of regular inspection of the external surface of the tubes.

One method adopted is to remove specially chosen tubes at each inspection and record the wastage, thus anticipating the time when the renewal of tubes will be necessary.

Shell and tube bundle with return bends

One advantage of the equipment already described is that standard tubes can be stocked which can be cut to lengths to recondition a number of plant items.

Where only one or two heat exchangers are employed it is sometimes preferred to use a removable bundle with return bends, thus eliminating the floating head joint. With this type of bundle it is essential to use high-quality solid drawn tubes. Adequate wall thickness must be maintained at the bends. While this presents no problem at the larger radii bends, some difficulty occurs with the centre tubes at very small radii.

When reconditioning these tube bundles a complete set of bent tubes has to be acquired; these can be expensive when compared with straight tubes. Nevertheless, when suitable conditions prevail, this type can have low maintenance cost. An advantage of this design is the ease of inspection, as all bends are available for hammer test.

Jacketed equipment

Chief problem associated with corrosion is the maintenance of jacketed equipment. Unless special materials have been employed to counter this trouble, wastage will usually occur, with consequent weakening of the jacket.

Frequently corrosion occurs at the level of condensate and a strap approximately 6 to 8 in. wide externally welded to the jacket often prolongs the life several years.

Where wastage is general it is usually preferable to fabricate new plates especially prepared for butt welding.

A special point to be considered when reconditioning this type of equipment, chiefly where steam heating is used, is the effect of vacuum in the jacket caused by the condensation when steam is shut off.

A common problem with jackets is 'silting.' Jackets frequently choke up at the lower section, often affecting the efficient drainage of condensate. Where such conditions are noted, it is advisable to fit suitable cleaning doors at appropriate locations.

Wastage of the main vessel often occurs from inside the jacket, and it is advisable at periodical general inspection to drill test the vessels at points suspected of wastage. These test holes should be calibrated for thickness and recorded, and finally made good by welding.

It is advisable to ensure that a suitable safety valve is fitted to all jackets.

In considering steam heating equipment, mention should again be made of steam trapping. When steam is first applied to a receiver of cold liquid, condensation can be considerable, and it is essential to install a suitable steam trap of adequate size and preferably of the continuous discharge type. Steam hammer on a piece of jacketed equipment can cause a failure.

Frequently jacketed equipment has some form of expansion joint or bellows and, while no appreciable difficulties are experienced when equipment is of a vertical design, some troubles may be expected when horizontal jacketed items are used. As one would expect, the sump formed by the bottom of the bellows is an ideal trap for solids, salts, etc., and quite often corrosion takes place and failure occurs. Large-size draining and cleaning plugs should be used with this design of plant.

A word may be said about jacketed pumps. Quite often, when dealing with viscous products, it is necessary to use steam jacketed pumps. Care should be taken to ensure complete drainage of jackets, especially when these pumps are sited in the open. During winter spells of hard frost, far too frequently we find cracked jackets as the result of faulty installation, choked drain cocks or leaking stop valves.

While on the subject of frost precautions, it is well to remember the steam trap. Closing down exposed steam plant for the night without draining the trap body is just asking for trouble.

Finally, a word about jacketed pipe runs which are often used when conveying viscous liquid long distances. This type of equipment is often made up on site and, if designed properly, can be extremely useful.

Great care must be taken to ensure satisfactory removal of condensate. With high temperature it is not advisable to construct jacketed pipe units longer than 20 ft. unless special provision is made for expansion differentials.

The fabrication of these pipes requires a special technique and, whenever possible, weld joints should be in compression. The steam pipe connections, connecting each length, should be designed to effect complate drainage of the preceding jacket. To ensure this condition it is essential that the steam flow follows the fall in the line and, in long installations where a continuous fall cannot be maintained, separate supply points must be fitted, the condensate being removed at each low point.

Jacketed pipe coolers are often constructed in banks and it is usual to have a gland arrangement at each end which allows tubes to be replaced easily.

High efficiency with this type of equipment depends entirely on the cleanliness of the jacket. Usually it is very difficult to maintain clean internal jacket surfaces and a considerable amount of water is required to obtain relatively poor heat exchange. Water treatment can often be proved economical when considered against high labour cost involved in jacket cleaning.

Cleaning of heat exchanger equipment

Although heat exchange is utilised in one form or another in many industrial plants, the importance of maintaining really clean equipment is seldom appreciated. The comparison of efficiency of performance between plant which has been rough cleaned and similar equipment which has been scientifically cleaned to base metal can only be appreciated if the heat transfer rates are measured.

An instance can be quoted in which a vertical tubular condenser was used to cool a gas. The normal procedure at plant overhaul was to brush through each of the 200 tubes which were 20 ft. long. Conditions obtained on recommissioning the equipment were considered satisfactory. Recently, after the so-called cleaning had been completed, each tube was cleaned again using a modern pneumatic vibrator-type cleaner. Approximately $1\frac{3}{4}$ lb. of fine scale was removed from each tube and when the performance was checked against the usual method a gain of some 10% in efficiency was noted.

The general practice of cleaning usually falls in one of the following categories: steam cleaning, chemical cleaning, mechanical cleaning and hand cleaning.

Steam cleaning

This method is relatively cheap, convenient and, when carried out at frequent intervals, quite satisfactory for many purposes.

Types of plant which come to mind include water-cooling equipment in which the jackets on tube surfaces acquire a slimy or oily film, heat exchange equipment where steam-soluble salts have formed on the surface and low-temperature equipment where waxy deposits have formed.

Fig. 4. The large variety of tools designed for the mechanical cleaning of heat exchangers.

This method is not satisfactory where hard scale or coke deposits have formed.

Chemical cleaning

Various forms of chemical cleaning have been practised for many years, but of recent years, with improved inhibitors and studied technique, large sections of plant can be cleaned *in situ*.

The usual equipment includes a vessel to hold the chemical, quite often an inhibited acid, a circulating pump fitted with suitable strainers, heating coils and various instruments to allow the operation to be carried out under controlled conditions.

It is interesting to recall that, during a recent visit to the U.S.A., a firm of contractors was noted to have specialised in this field and had worked up a large business extending over a wide area. The firm undertook to provide all the necessary equipment, personnel and supervision for cleaning many varieties of plant, of which heat exchanger equipment formed a fairly high proportion. The work was carried out on a contract time basis and formed a good investment for both large and small industrial undertakings.

Types of plant which lend themselves to this method include: chemical plant, refining equipment, heat exchangers of many varieties and treatment plants.

Mechanical cleaning

Mechanical cleaning is perhaps the most common method of cleaning heat exchanger equipment.

The various methods include the wide variety of scaling equipment, pneumatic vibrators, mechanically-driven wire brushes, wet sand blasting and, for large, heavy constructed pipestills, sometimes burning, carried out under mechanically controlled conditions.

Some appreciation of the variety of tools which have been designed specially for this type of operation are shown in Fig. 4. Two common forms of drives for this tool are the flexible tube powered by electric motor, air-driven motor or, for large tubes, the air-driven turbine. The former finds favour for tubes up to 1½-in. bore. For large tubes the air turbine is considered more robust and suitable for the heavy duty for which it is required to perform.

For many conditions with tubes above 2 in. the pneumatic vibrator (for want of a better word) is found to be satisfactory. This tool uses air at 90 to 100 p.s.i. and delivers hundreds of impulses per minute and has the effect of using miniature hammers.

The mechanically-driven wire brushes are used for many duties and can be considered a cheap method of cleaning.

A somewhat new technique in tubular cleaning is the use of wet sand blasting. Some remarkable claims are made for this method and probably its use will be more general in the near future.

The last method of burning is usually confined to large pipestills of welded construction in which hard coke formation has formed on the inner walls of the tubes. The burning is started by applying heat and is maintained under controlled conditions by the utilisation of correct quantities of steam and air. It is not advisable to use this method on equipment with rolled expansions as the cleaning is so thorough that particles of coke between tube and header wall are burned and leakage usually ensues.

Where the equipment is designed to allow the method to be used, a remarkable saving in time and expense can be made. The method is found to be more popular in the U.S.A., but its adoption in the U.K. will probably increase.

Materials of construction

An important feature of heat exchanger design concerns the materials of construction. This is especially true when considering subsequent maintenance and the choice of materials must be governed by the duty and conditions under which the equipment is to operate. This factor should be borne in mind when contemplating the transfer of a piece of equipment for service on a different process or under different operating conditions.

It is usual to design a heat exchanger to carry out a particular duty and it should not be considered a universal item of plant. The effect of possible electrolytic action and corrosion should be considered.

The British Standards Institution has published several specifications governing the materials for various industries and, where appropriate, these recommendations should be followed.

The actual physical conditions of the material are important, as considerable stresses are set up in heat exchangers, especially where vibration in unavoidable.

Care and maintenance of tools

The tools used for the maintenance of heat exchanger tubulars are not cheap and care should be taken to obtain the greatest return for the expense involved.

Such items as tube expanders, although in common use, cannot always be obtained 'off the shelf' and frequently four to six months is quoted for replacements. In the large sizes it is much longer, and care should be taken to clean rollers and mandril before each tube rolling, and the use of suitable extreme pressure lubricants is strongly recommended.

With regard to pneumatic tools, the greatest care must be taken to avoid damage caused by moisture from the air. It is strongly recommended that line lubricators be used wherever possible and that turbines and motors should be totally immersed in light oil after use. A useful method of preserving this type of equipment is to maintain a small tank with sufficient gas oil or spindle oil to cover the tools, after which they are placed on a rack above the oil, but still inside the tank. The tank should be fitted with a hinged lid and the initial charge should last several years. The same care should be taken with power drills for driving the expanders. Where electric-powered tools are used it is essential to carry out scheduled inspection and earthing tests.

The general condition under which site repairs are carried out generally presents a hazard with electric tools and, for large-tube maintenance, the pneumatic tools are usually preferred. Where a number of heat exchangers have to be maintained the use of an impact wrench in dismantling and rejointing is invaluable. Again this tool is expensive and should be treated with utmost care.

Among the actual cleaning tools which require care can be mentioned the wheel brush which is used in conjunction with an air-driven turbine and is made up of assembled cutter wheels (see Fig. 5), the porcupine head knocker, the spring-loaded wheel brush and the knurling head. A collection of cleaning tools is shown which gives some idea of the importance which is attached to cleaning of tubular equipment.

The usual method of assessment of remaining life of tubular equipment is by calibration, and special graduated calipers have been designed for this purpose. These calipers should be handled carefully and periodically checked by the use of standard ring gauges.

Special apparatus has been designed to give visual inspection of the tube wall, and again an expensive tool should be carefully handled.

In connection with large pipestills it is essential to examine the tubes externally, and special gap gauges are used. Once a tube is swollen beyond the allowable limit, indicated by the fact that the gauge will not pass over the tube diameter, it should be renewed. With this type of tubular pipe exchanger the connection between tube and tube is accomplished by fitting return headers rolled or welded to the tube ends. These headers are fitted with plugs held to position by various types of strong-back with jacking screw.

Time can be saved by loosening these screws immediately after the unit has been steamed through. An impact wrench is desirable for this operation, but when this expensive tool is not available a short-handled stiff ring spanner, which can be hit with several sharp blows using a sledge hammer, should be provided.

The large pipe units are usually housed in brick furnaces and the combustion space is very considerable. With the use of oil or gas firing, care must be taken to ensure the space does not fill with combustion gas mixture while the burners are unlit. This danger always exists and it is usual to provide large explosion doors to allow free vent for the gases should such an incident occur.

Because explosions seldom happen, the maintenance of these doors is often neglected. Owing to the extreme heat the hinge pins seize and the doors warp. These fitments should be examined and made workable at each overhaul and should be treated in the same manner as one would treat a safety valve.

Special applications

Quite frequently, with multi-tube exchangers, a failure of a single or few tubes occurs. When tubes are available it is usual to renew these tubes, but should plugging be necessary it is common practice to fit dummy tube ends. It is necessary to drill out the tubes and remove if possible. Great care must be taken to clean out the expansion grooves, after which short tubes, one end of which has been suitably blanked, are inserted and rather heavily rolled. An alternate method is to make special collar plugs and fit a stay bolt through the centre of the tube.

It sometimes happens that tubulars are used for duties in which the two fluids or gases, while individually are non-corrosive, become active or highly corrosive if contaminated. For instance, liquid SO_2 may have to be cooled with water and possibly steel equipment is used. Provided no leakage takes place, many years' service will be obtained. With only a slight contamination, failure will occur in a few hours.

Fig. 5. Cutter wheels for the wheel brush employed in conjunction with an air-driven turbine.

A special technique has proved satisfactory for such applications and detailed procedure will be given. Before inserting tubes the outer faces of the tube plates are countersunk at 45° to a depth of approximately $\frac{1}{8}$ in. for tubes up to $1\frac{1}{2}$ in. diameter. The tubes are fitted, leaving $\frac{1}{16}$ in. of projection, and heavily rolled. An air-pressure test of 100 p.s.i. is applied and each expansion tested with soap solution. Where facilities are available the unit is submerged in clean water and tubes inspected for bubble leak at expansion. If satisfactory, the tube end is welded, using a $\frac{1}{8}$-in. electrode which seals the bottom of the countersunk hole to the tube. Each tube end is then caulked either by hand or with a small pneumatic caulking hammer. As a final operation the end is seal-welded between face of plate and tube end. The air test is again applied and, if the test is again satisfactory, long service life can be expected.

Under working conditions in which liquids may contain foreign matter, *e.g.* grass, bits of wood or rags in cooling water, the provision of suitable filters which can be changed over during the running of the plant can often be justified. To ensure that satisfactory performance is being obtained, the fitting of thermometers at inlet and outlet of the flow stream is highly desirable though seldom done. Temperature differences should be recorded for cleaned or new equipment and compared at prescribed intervals.

A final word on handling of tubular bundles. When slinging a tube bundle, especially if constructed of non-ferrous material, it is essential to avoid lifting on the tubes.

A useful method is to maintain special wire slings for this duty. The wire is threaded through timber runners, usually four, before splicing the eyes. Before the actual lift is taken, the timbers are equally spaced at the lower half of the tube bundle and this forms complete protection for tubes and baffle plates.

In large plants the use of the modern straddle-type truck has been found to be extremely useful.

Industrial gases. In an attractive brochure with the title 'All in the Day's Work,' the British Oxygen Co. shows the various uses to which its products and processes are put in shipyards, steelworks, factories and hospitals. Mention is made of the new Chemicals Division of the company.

Fatty acid derivatives. The Chemical Division of Armour & Co. Ltd. have issued two booklets for those interested in fatty acid derivatives. One of these, 'The Chemistry of Fatty Acids,' describes a number of reactions of fatty acids, such as hydrogenation, sulphonation and sulphation; the production of acid anhydrides, nitriles, amines, amides, etc. In the second booklet, entitled *Armids*, a table of the whole range of aliphatic amides produced by Armour is given, together with the main properties. Some suggested uses such as in printing inks, varnishes, plastics, asphalt compounds, dyes and various emulsions are described. These high-melting, wax-like *Armids* are highly water repellent.

Our new address

The address of Leonard Hill Ltd., publishers of CHEMICAL & PROCESS ENGINEERING *is now: Stratford House, 9 Eden St., London, N.W.1. Telephone: Euston 5911. Will all correspondents please cancel our old address from their records and substitute the new one.*

New Chemical Plant Factory

On the new industrial estate at Manor Royal, Crawley, Sussex, one of the most important projects has been the building of a new factory and foundries by the A.P.V. Co. Ltd. and its subsidiary, A.P.V.-Paramount Ltd. The total investment is in the region of £1 million. Recently we visited Crawley to see the manufacture of plant in stainless steel, aluminium and copper. Here is a description of the new installations which embody the most modern welding, fabrication, foundry and materials handling equipment.

THE A.P.V. Co. is one of the largest manufacturers of plant in stainless steel, aluminium and copper for the dairy, brewery, food, chemical, oil and varnish, beverage and pharmaceutical industries. It was founded at Wandsworth, London, in 1910 as the Aluminium Plant & Vessel Co. Ltd., by Dr. Richard Seligman for the fabrication of industrial tanks and vessels in aluminium. Dr. Seligman held the patent for the autogenous welding of aluminium in conjunction with a Swiss firm.

In 1922, Dr. Seligman invented the plate-type heat exchanger and this device, known as the *Paraflow*, is now widely used in dairies for the pasteurisation and cooling of milk, in breweries for wort cooling, beer pasteurisation and other duties and in many other industries for the pasteurisation, heating and cooling of potable liquids. It is today the company's principal product.

The A.P.V. Co. have developed more and more as process engineers and today design and manufacture complete installations for the industries they serve.

A.P.V.-Paramount Ltd. is the subsidiary company of A.P.V. which operates the aluminium and stainless-steel foundries. It was formed in June 1952 to take over the stainless-steel foundry of the former subsidiary company, Paramount Alloys Ltd., of Slough, Bucks, and the aluminium foundries of the parent company.

The rapid growth of A.P.V. in recent years had resulted in an unwanted dispersal of its production facilities among four factories at Point Pleasant and Garratt Lane, Wandsworth, London; at White City, London; and at Slough, Bucks.

The restrictions of building and the lack of adequate space eventually decided the company to move all its production facilities and head office to an entirely new factory and foundry to be built in the New Town at Crawley, Sussex. The handicaps of improvisation could then be removed and every advantage taken of the most up-to-date ideas in factory planning and equipment.

This move is being carried out in two stages. The first stage is now completed and includes the fitting, machine, press and polishing shops and also the foundries which are operated by A.P.V.-Paramount. The head office and the coppersmith shops remain at Wandsworth and will constitute the second stage of the move soon to be commenced.

Some 1,400 people are involved, and houses are being provided in the Crawley New Town for all who require them. Five hundred people are already working in the new factory and most of these are housed in the New Town.

The move has thus considerable social implications, as it involves a radical change in the way of life of A.P.V. employees. From being widely dispersed and around London they are now concentrated in a single, compact community. A noticeable feature of the move has been the loyalty exhibited by all members of the company, the overwhelming majority of those up to the present affected having moved to Crawley. The loss of skilled personnel has been insignificant.

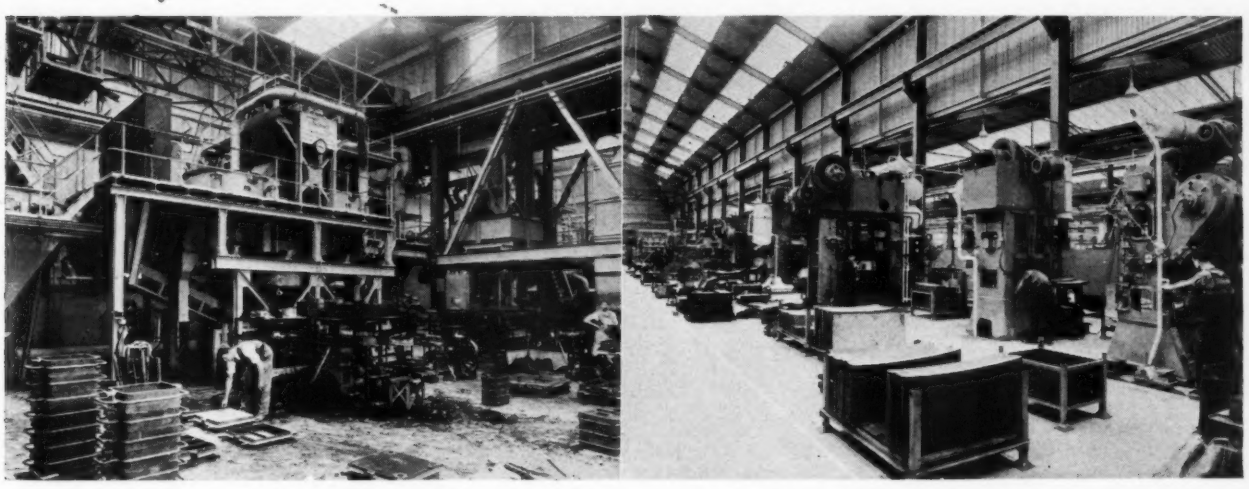
The factory block

The factory and foundries occupy a 17-acre site at Manor Royal on the industrial estate of the Crawley New Town. They cover an area of 200,000 sq. ft. and are by far the largest works in the Crawley New Town. The factory and the foundries form entirely separate blocks each with their own administrative offices.

The factory block covers 128,800 sq. ft. and consists of five 475-ft. bays with parts of three further bays which will be extended later. The frontage is taken up by the works offices.

The layout of the factory provides for a general flow of production from the front to the rear. The stores take up the front ends of the bays and are served by the large goods entrance that forms the most noticeable feature of the frontage. The machine, press and polishing shops stretch across all bays while the fitting shop occupies most of the large 60-ft. bay and one other.

Travelling cranes serve the bays from the stores in front to the doors in the rear for dispatch of the finished products. A broad gangway across the bays provides for transport by trucks from one bay to another. Considerable attention has been given to material handling and fork-lift trucks are widely employed with box and other pallets. Materials and small parts in storage and in course of production



Left: **The sand reconditioning plant in the foundries. Used sand is dropped from the boxes through gratings in the floor and falls on to conveyors in tunnels which deliver it to the reconditioning plant.** *Right:* **The press shop in the factory. The presses are producing heat exchanger plates, some of which are seen in the foreground.**

remain at all times in these pallets right up to final assembly.

The machine tools are of the latest types and wide use is made of automatics and semi-automatics for the production of stainless-steel pipe fittings and other repetition parts. A number of ingenious machines and methods are employed, having been designed by the company's engineers for its special requirements.

The factory building is of welded steel, portal-framed construction giving free headroom. The most noticeable feature of the factory on first entering it is the bright colouring, it being an outstanding example of the application of the British Standard colours for factories. The steelwork is in blue, while cranes and all moving parts are in red. Machinery is in green and all pipes and mains are in various colours according to their purpose. The roof is of aluminium and glass which, with the blue steelwork, provides a very cheerful, light effect.

A great deal of attention has been given to heating and ventilation and an equable temperature is maintained throughout the year. The boiler house covers 3,450 sq. ft. and is capable of supplying 30 to 36 million B.Th.U./hr.

The lavatories and cloakrooms are most spacious and well fitted.

The foundries

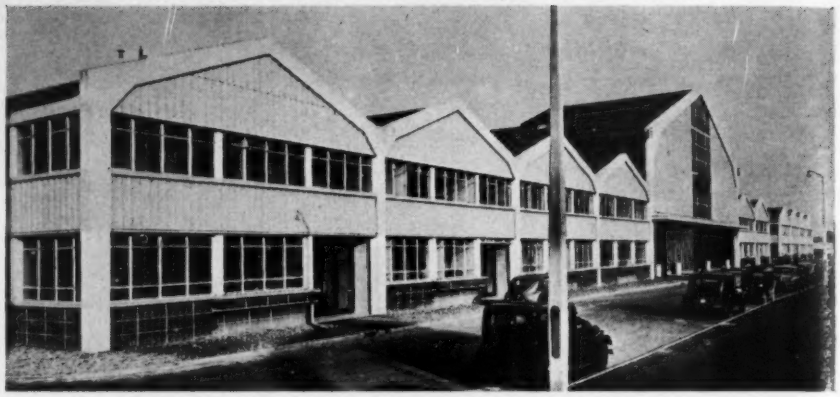
Before the stainless-steel, aluminium and copper-base alloy foundries were planned, the leading foundries of the U.S.A., Europe and this country were visited to glean ideas and, therefore, the new foundries can be said to embody most of the applicable modern ideas in planning and equipment. They are mechanised up to the limit possible with the considerable variety of work handled.

In particular, material handling has been given a great deal of attention, as it is estimated that the production of 1 ton of castings requires the movement of between 100 and 200 tons of sand, metal, moulding boxes and castings.

The latest type of sand reconditioning plant is installed and this forms an important part of the construction of the two foundries. The used sand is dropped from the boxes through gratings in the floor and it falls on to conveyors running in tunnels which take it to the reconditioning plant. It is then served back by overhead belt conveyors to hoppers which feed the moulding machines.

The building consists of two 60-ft. main bays, 250 ft. long, one being the stainless-steel foundry and the other the aluminium and copper-base alloy foundries. A 20-ft. middle bay houses the furnaces and their auxiliary equipment, including the generators. The stainless-steel furnaces are electric high-frequency and arc types, while the aluminium furnaces are fired by fuel oil.

The offices, stores and pattern shops occupy the frontage of the building and the fettling shops the rear end. The *x*-ray and other test rooms run along the side of the aluminium foundry. A large fume- and dust-extraction plant is installed and the working conditions are unusually bright and clean for a foundry. Here again lavatories and cloakrooms are large, warm and well equipped and showers are provided.



The new buildings at Crawley which stand on a 17-acre site. The factory is nearest the camera and the foundries are housed in the four bays on the extreme right. Total area of factory and foundries is 200,000 sq. ft.

The stainless-steel foundry operated by A.P.V.-Paramount. Like the adjoining aluminium foundry, it is 250 ft. long and 60 ft. wide. This view is from the sand reconditioning plant. Sand is conveyed on the overhead belt on the left and falls into the hoppers which feed the moulding machines. The stainless-steel furnaces are electric high-frequency and arc types. The aluminium furnaces are fired by fuel oil.

Students' organic chemistry

Much new material has been included in this third edition of this textbook,* which first appeared in 1938. Otherwise the same pattern has been followed, that of a comprehensive treatment of the subject for the student beginning his study of chemistry, which will be thorough enough to bring him to a required standard of proficiency and to win his interest in industrial organic chemistry.

Theoretical consideration of the electronic configurations of elements has been expanded, and completely new material inserted into the book includes data on the mechanism of reactions of unsaturated systems; resonance phenomena of aldehydes, ketones, acids, tautomeric systems, aromatics and dyes; hydrogen bonding; transition state theory of reactions; Walden inversion; and biosynthesis of sugars.

The newer conventions on the optical nomenclature of sugars and amino-acids have been included in an expanded section on nomenclature, while the preparation of a variety of isotopically labelled organic compounds now forms part of the section on synthesis.

The following new reactions have been introduced: vinylation by acetylene, the Leuckart reaction, Ziegler bromination, crossed Cannizzaro reactions, the oxo process, the Mannich reaction, reduction with lithium aluminium hydride, and the properties of copper chromite catalysts.

Among the newer products discussed are: silicone polymers, DDT, 2, 4-D, benzedrine, chloromycetin, cortisone, vitamin E, paludrine, phenothiazine, penicillin and thiouracil.

**Textbook of Organic Chemistry*, by G. H. Richter. Third edition. Chapman & Hall, London, 1952. Pp. 762 including index. 54s. net.

Plant and Equipment

Down-hand welding positioner

To meet the need for a simple welding positioner, American-designed *Aronson* machines are now being made under licence by a British firm. Two sizes are now available for loads of 5 and 10 cwt.

A simple balance principle is employed so that, however bulky or heavy a work-piece may be, if it is mechanically brought into balance, virtually no effort is required to move it.

The manufacturers claim that these machines make a considerable saving in capital and running costs when compared with conventional positioners, as no motors, switchgear, cranks, gear boxes or other mechanical aids are used.

The sequence for setting up a work-piece on the machine is briefly as follows:

The tacked work-piece or the work-piece-cum-jig is placed on the rotating work-table by the operator. He balances it as closely as possible on the rotational axis of the work-table. The arm to which the work-table is fixed is now tilted so as to bring the true centre of gravity of the work-piece in line with the rotational axis of the main shaft. The work-piece can now be rotated through 360° in either the vertical or horizontal axis by the touch of a finger, allowing the operator to present every weld in the downhand position.

A useful feature is that the whole positioner can be rotated through 360°, an advantage when the machines are used in line production, as the work-piece can be loaded in one position, swung 90° to another for welding and swung a further 90° for unloading.

An ingenious cruciform-shaped work-holder with sliding, adjustable arms can be provided for attaching to the work-table.

Known as the *Twinner-Aronson* universal balance positioners, the machines are made, for all markets other than North America, by Donald Ross & Partners Ltd.

Air control device

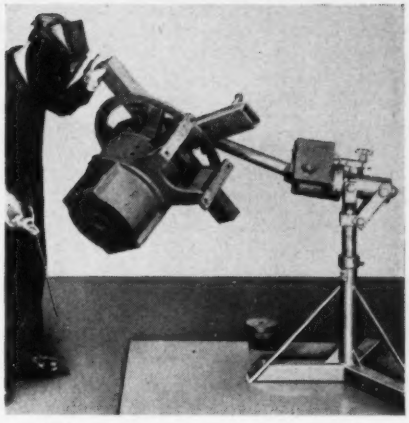
The *Pneumerstat* is an instrument combining the duties of a bubbler chamber pressure-reducing valve and a needle valve, for controlling the supply of compressed air when used for purposes such as the indication of content, level or pressure. It has also been used for the regulation of a slow feed of water for laboratory tests, and in the continuous sampling of gas for analysis of shed atmosphere and absorption tower outlets, etc. Advantages claimed for it are that it gives a constant flow, eliminates the human element, can be used for open or closed vessels under pressure or vacuum, prevents air leaks since there are fewer joints, and reduces installation costs.

By the action of the incoming compressed air on a diaphragm mounted on springs within the instrument, valves are actuated so that the pressure of the air in the primary and secondary chambers is automatically controlled. From the secondary chamber it passes out through a bubbler chamber, which contains a special fluid and is so designed that the air must bubble through this liquid and give an indication of the flow through the instrument.

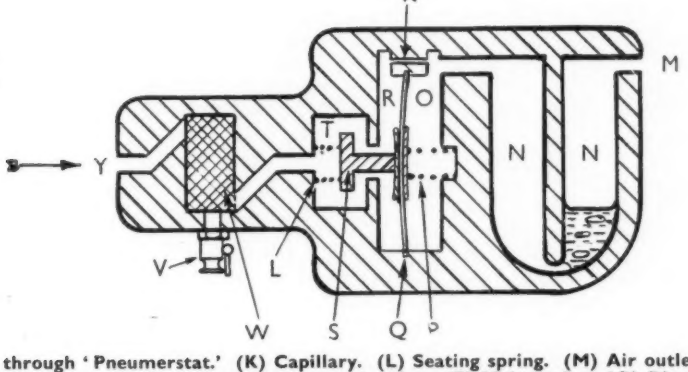
The *Pneumerstat* has been developed by Williams & James Ltd., in co-operation with the Dyestuffs Division of I.C.I., for whom it is in quantity production. It is designed for panel mounting.

Versatile valve lubricant

It is customary in chemical, petroleum and other plants handling a diversity of line fluids to use several different valve lubricants. Audley Engineering Co. Ltd. have now formulated a single lubricant, *Audco* No. 631, which, they claim, is efficient on a wide range of services at high and low temperatures. It is soft at room temperature and its viscosity varies little over the temperature range 0 to 620°F. Thus, when charged with this lubricant, a valve which is normally operated at, say, 600°F. will turn readily even when cold. The makers state that a further advantage is that it does not readily carbonise at temperatures higher even than 620°F., eliminating the risk of the grooves becoming blocked with hard residue. Lubricant No. 631 can be used in valves handling such diverse fluids as sulphuric acid, brine, hydrocarbons, bitumen and diphenyls.



Welding positioner operating on balance principle.



Section through 'Pneumerstat.' (K) Capillary. (L) Seating spring. (M) Air outlet. (N) Bubbler chamber. (O) Secondary diaphragm chamber. (P) Main spring. (Q) Diaphragm. (R) Primary diaphragm chamber. (S) Valve. (T) Upstream chamber. (V) Drain valve. (W) Air filter. (Y) Air inlet.

Sifter for granule preparation

A new machine for the preparation of granules is known as the *Rotorsift*.

It is designed primarily for the sifting of granules after wet granulation; owing to the special design of the rotor, a minimum of 'fines' is produced and it eliminates laborious hand sifting.

It is claimed to have advantages over other types of sifting machines: it produces less dust; its positive roller action forces the material through the screens; and it will in some cases eliminate the dry granulation process usually carried out on oscillating-type granulators.

It can also be used for the blending of fine powders up to 60 mesh.

On test in a manufacturing plant for two years, this machine has proved an economic unit in the production department. From this test a sample production was taken and 1 cwt. of previously processed 12-mesh wet was reduced to 16-mesh dry per hour approximately.

This machine is of rigid construction and particular attention has been given to easy cleaning of the rotor and container. The screens are easily changeable and the whole is totally enclosed.

The drive is taken from a motor and vee belts into a Holroyd 'H' type vertical worm reduction unit. The wormshaft is of nickel steel, case-hardened and accurately ground on the threads, the worm-wheel being of *Holfos* bronze, both to British Standard Specification. Sizes of

screens depend upon individual requirements; as standard a range of three screens is supplied.

The machine can also be mounted on castors to enable it to be moved to various positions as may be found convenient; this, of course, is dependent on an electricity supply being available. Makers are Manesty Machines Ltd.

Continuous lead-casting machine

A new design of continuous lead-casting machine recently installed at the works of a chemical producer in Cheshire has a capacity of 10 tons/hr. at a running speed of 2.52 ft./min. The machine has an overall length of 32 ft. 3 in. and is 6 ft. 2 in. high with a total all-up weight of 9 tons. The framework is built up of mild-steel channels and angles, riveted and bolted together, carrying the driving sprockets supporting the rails upon which the moulds run. The distance between the centre of the driving sprocket and the centre of the radius of the discharge end rails is 28 ft.

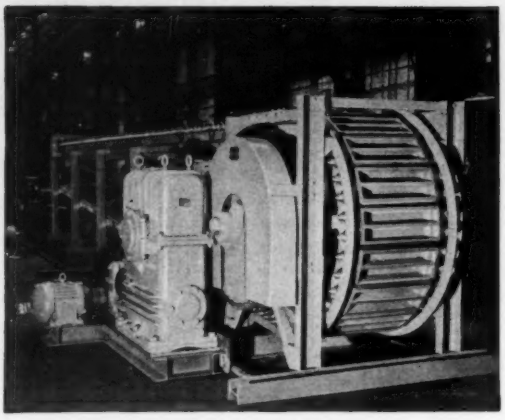
Each of the 88 moulds, which form the basis of the machine, has a capacity of 1 cwt. in two pigs of 56 lb. weight each, and they are arranged to travel from the pouring point along the rails, which have a gradient toward the discharge end of $\frac{1}{16}$ in./ft., thereby reducing slightly the power required from the drive. The moulds form a continuous train around the track of the machine except for a space at the discharge end, where, by means of gravity and a slight bumping effect, the solidified pig is discharged.

The moulds are in no way connected with one another; each travels upon four bushed track rollers and each roller is fitted with a grease nipple for lubrication. At the driving and discharge ends additional retaining rails are fitted on the outside radius to guide the moulds around the track.

Lead is poured at a temperature of 400 to 420°C., the flow being controlled by manual operation. Contraction of the lead during its cooling period assists discharge and the pig is ejected with the mould in a vertical position, the ejection being assisted by each mould bumping the preceding mould. After discharge the moulds return by gravity along the lower rack to the feed end.

The driving arrangements consist of a 5-h.p., 955-r.p.m. motor driving two double worm reduction gears in a reduction box mounted on a combined fabricated mild-steel bedplate. The reduction box output shaft is fitted with a spur gear pinion driving a spur gear wheel which is in turn coupled to a driving sprocket engaging with the inner side of the track rollers. A shear pin is fitted to this drive to avoid damage in the event of an overload.

The method of propulsion is for the toothed sprocket to engage with the bushed track rollers at the drive end and traverse them around the inner radius of the slide rails, the actual drive being transmitted by each mould pushing against its preceding mould.



Lead-casting machine.

The time cycle allows ample time for cooling and enables the pigs to be ejected in the solid state. At the same time any dressing which the moulds may need may be accomplished during the return run to the drive sprocket.

The machine was designed and installed by General Electric Co. Ltd.

Temperature indicating paints and crayons

The B.A.S.F. *Thermocolour* temperature indicating powders are now available in Britain from Allied Colloids (Bradford) Ltd. These products are applied in the form of a paint with industrial methylated spirits and are claimed to give very accurate indication of thermal zones under observation. They are particularly useful for non-destructive material testing and for control work in industry generally, wherever heat distribution presents a problem.

A further addition to the range of chemical temperature indicating products are the A. W. Faber *Thermochrom* crayons, which work on a similar principle to the paints. These products, which are also available from Allied Colloids, are offered in handy boxes of 12 or 15 and are ideal for carrying around during the day's work in the factory or laboratory.

Electronic control instrument

The Evershed electronic repeater is an instrument for transmitting information to a distance and for controlling distant apparatus. The following measurements can be repeated: Electrical quantities such as amperes, volts and watts; steam, water and gas pressure; steam or water flow; temperature; liquid levels; gasholder stock; degree of opening of valves, sluice gates, etc. Other functions that can be performed are the selection and control of distant switchgear and the summation of two or more measured quantities such as electrical power or water flow, the information being transmitted to a central control point. The signals transmitted may also be used with Evershed electronic process controllers giving proportional integral and derivative forms of control. The electronic repeater consists of a transmitter connected by pilot lines to one or more distant receivers of the indicating, chart recording or integrating types, or to process controllers. The transmission system is fully automatic and, within wide limits, is not affected by variations in supply voltage, frequency or line resistance, while the number of receivers can be varied at any time without affecting the accuracy of transmission. The repeater operates on alternating current mains, while a direct current of a few milliamperes flows in the transmission circuit. Only two wires are required between transmitter and receivers, the latter being connected electrically in series, and the apparatus can be arranged for transmission over Post Office lines, provided these are continuous. The repeater is fully described in a new publication (266) from Evershed & Vignoles Ltd.

Welding electrodes

Five new electrodes for electric arc welding made by Murex Welding Processes Ltd. are now going into full-scale production. The *Speedex* electrode is a mild-steel unit designed to facilitate very high-speed manual arc welding under normal operating conditions and with normal penetration. The deep-penetration *Deepex* electrode has been designed to produce butt welds in the downhand position in mild-steel plate for thicknesses up to $\frac{1}{2}$ in. without edge preparation. Thicker material can be welded by the adoption of partial preparation. The low-hydrogen type of electrode, *Ferex B*, is suitable for the welding of medium alloy steels and mild steel. *Contex* has been designed primarily for the welding of downhand and overhead joints in mild and low-alloy high-tensile steels by using the 'touch welding' technique. It thus simplifies the production of neat and uniform weld deposits. Lastly, for the welding of nodular and other types of cast iron with high ductility, there is *Cinnifex*. The deposit gives an analysis of 55% nickel and 45% iron. The electrode is also suitable for welding ordinary cast iron where strength is required.

For further details of plant and equipment please use the coupon on page 222

EFFLUENT DISPOSAL

Symposium organised by junior chemical engineers

THE question of water purity standards was frequently touched upon during the recent symposium on effluent disposal held in London and organised by the Graduates' and Students' Section of the Institution of Chemical Engineers. Most speakers expressed the view that there was as yet insufficient knowledge of the subject to justify the formulation of rigid standards.

The symposium was divided into two parts. The morning session, presided over by H. W. Cremer, C.B.E., M.Sc., F.R.I.C., M.I.Chem.E., dealt with the 'National Problem,' while the afternoon session, presided over by J. T. Calvert, M.A., M.I.C.E., F.R.I.C. (John Taylor & Sons), was concerned with the 'Industrial Problem.'

DR. B. A. SOUTHGATE, Director of Water Pollution Research, D.S.I.R., dealt with the problems of effluent disposal in relation to local sewage systems. He emphasised the need for more accurate analysis of effluent. Research was proceeding on this problem and a suitable method of analysis should soon be found.

MR. H. CARY GIBSON, Director of Freshwater Biological Association, Windermere Laboratory, described the delicate and complex pattern of aquatic life and the far-reaching effects of any change in the condition of the water.

MR. C. D. MULVEY, secretary of the Anglers' Co-operative Association, said that his organisation was sympathetic with industry and had no wish to impede production. Where there was needless pollution of rivers, however, the A.C.A. was prepared to fight it.

River Board's viewpoint

The last speaker before the lunch interval was MR. J. I. SPICER, Chief Pollution and Fisheries Officer, Trent River Board, who said that the objects of the river boards were to secure co-operation between industry and all users of water and to get at the root cause of river pollution. The subsistence of fish life was regarded as a basic standard of water purity applicable to the interests of all users of surface waters. The river boards were prepared to concede to industry the task of setting a practical standard, but it was the duty of industry to be specific in stating its difficulties instead of making unreasonable generalisations concerning national production interests.

At the afternoon session MR. C. LEA, Imperial Chemical Industries Ltd., reviewed the legal and financial aspects of effluent disposal from the manufacturer's point of view. Three classes of effluent had to be considered in planning an industrial site—domestic sewage, trade effluent and surface water—and provision of an adequate drainage scheme was the first essential. Present arrears in expenditure on effluent disposal were somewhere in the region of £250 million. A drainage scheme for an industrial site would mean heavy expenditure not only for the factory owner but also for the local authority. Speaking of the degree of purity to be aimed at in treating effluents, Mr. Lea said it was not possible to arrive at suitable standards at present.

Disposal plant

The subject, 'Plant and Equipment,' was dealt with jointly by MR. R. F. STEWART and MR. C. J. SMITH (Dorr-Oliver & Co. Ltd.). Mr. Stewart defended industry, pointing out that many manufacturers take effluent plants into consideration as an essential part of the design of their plant.

Dealing with types of equipment, Mr. Smith said a blending tank was a major item of expenditure since it had to be very large. If the rate of input fluctuated over a period it was best to have a tank capable of holding the total input during that period, thus obtaining an almost continuous process. In planning the economic layout of the plant, gravity rather than pumps should be used wherever possible for conveying liquids.

Circular settling tanks were preferred to rectangular tanks in most cases, as they took up less space; also the rectangular tanks were prone to 'short circuiting,' which reduced their efficiency.

In flocculation, small particles suspended in a liquid were slowly agitated so that they combined with each other to form flocs. But if the liquid was afterwards made to overflow into a sedimentation tank the flocs were likely to disintegrate during the overflow. This problem could be avoided by use of a 'clariflocculator,' which consisted essentially of a large circular tank containing a central container. This inner container was the flocculator, agitation being effected by means of fixed and moving baffles. The walls of this container did not extend to the bottom of the tank, so that the settling flocs could pass to the outer tank, or thickener.

Radioactive effluents

MR. H. J. BLYTHE, of the Atomic Energy Research Establishment, Harwell, dealt with the disposal of radioactive effluents. Whereas most establishments have three drainage systems, at Harwell there are four—the fourth being for the disposal of radioactive waste. To each building are attached a number of delay tanks, and these are divided into two types: for medium- and low-activity effluent, the latter being delayed as a precautionary measure. Highly active effluent was generally of negligible quantity and was disposed of by means of special flasks. The delay tanks, which are of 500- to 1,000-gal. capacity, are not fitted with bottom outlets. For extra safety each of the medium-activity tanks is contained in another tank on the 'cup-and-saucer' principle. From there the waste is led away to two 300,000-gal. tanks. Whether treatment is necessary before disposal depends on the degree of radioactivity.

The problems of effluent disposal in the gas industry were summarised briefly by MR. J. J. PRIESTLEY, of W. C. Holmes Ltd. The gas industry was growing larger each year and the effluent disposal problem was growing with it. At present the gas industry produced about 6¼ million gal./day of effluent liquors. The two salient features of the problem were: (1) the growing number of modern-type carbonising plants, which not only produced a more toxic waste liquor than the older plants but produced more of it, and (2) the changing pattern of the industry, resulting in fewer but much larger works. This meant that there was a greater quantity of waste liquor concentrated in one municipal area and the problem of disposal was correspondingly more difficult.

Speaking of the cost of effluent disposal, Mr. Priestley made the point that this is part of the total cost of gas production, and should be regarded as such. There is no gas works in the country that achieves finality in its effluent treatment, with the sole exception of the big new works at Tingley, Yorks, which is equipped with a full-scale effluent plant.

MR. F. F. ROSS (British Electricity Authority) dealt with the waste heat disposal methods of the B.E.A. As much use as possible was made of cooling towers before returning water to the rivers. Much criticism had been levelled at power stations for stirring up mud in rivers and because many fish were killed through the water being heated to an unnatural temperature. But the statistics given in support of these complaints were based purely on laboratory experiments and the situation was not so serious in actual practice. Mr. Ross said he knew of fishing stretches where the water was at 90°F. Further, since the cooling process reduced the amount of effluent, the river water left the power station purer than it had originally been.

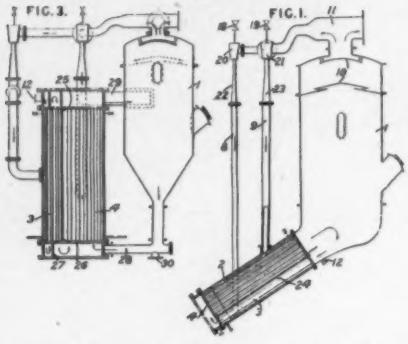
Before throwing the meeting open to general discussion the chairman said he would like to make the point that, far from being of purely nuisance value, the operation of an effluent disposal works frequently proved to be a paying proposition for the manufacturer.

Chemical Engineering Invention

MONTHLY SUMMARY OF BRITISH PATENT CLAIMS

Thermo-compression evaporators

This evaporator consists of calandria tubes and two thermo-compressors in which the evolved vapour is compressed. One of the thermo-compressors supplies compressed vapour to the tubes first traversed by the liquor under treatment, and the other thermo-compressor supplies compressed vapour to the tubes in which the main evaporation takes place.



The evaporator shown in Fig. 1 has an inclined calandria 2 with a preheating section 3 and an evaporator section 4 separated by plate 24. Both sections are connected to thermo-compressors by pipes 8 and 9, respectively. The thermo-compressors are supplied with steam through valves 18 and 19. The liquor, supplied at inlet 12, flows downwards through the preheater tubes and upwards through the evaporator tubes. Vapour is disengaged in separator 1, escapes past baffles 10, and is in part condensed in a condenser attached to pipe 11. The remaining part of the vapour is drawn into chambers 20 and 21 of the two thermo-compressors. The vapour is compressed and mixed with steam in each chamber, and the two streams pass to the calandria sections through combining tubes 22, 23 and pipes 8, 9. Combining tube 22 operates at a 21-in. vacuum, while the pressure in combining tube 23 may be any value between a partial vacuum and ½ p.s.i. (gauge). The cross-section of the calandria may be circular or elliptical.

In Fig. 3, the calandria is vertical and provided with headers 25, 26. The preheater section 3 has division plates 27 so as to cause multiple travel of the fresh feed, which is admitted through inlet 12. The liquor under evaporation circulates between the evaporator section 4 and the separator 1 by way of tubes 28 and 29. Concentrated liquor is drawn off continuously, if desired, at outlet 30. A film-type evaporator may be operated according to the principle of the invention. Specifications 384,741 and 387,598 are referred to.—640,946, *W. C. Mason and W. W. Hutcheson.*

Synthetic rubber washers

A synthetic rubber washer which swells on contact with petrol, oil or water is used to seal a hose coupling. The washer may comprise:

(*a*)	*Parts*
Polychlorobutadiene	69.7
Di-orthotolyl guanidine	0.4
Polystyrene	4.2
Carbon black	17.4
Phenyl-alpha naphthylamine	1.4
Litharge	6.9

or

(*b*)	
Copolymer of butadiene and acrylonitrile	30.6
Natural rubber	30.0
Mineral oil or di-butyl phthalate	5.5
Phenyl-alpha naphthylamine	1.2
Zinc oxide	3.1
Carbon black	27.6
Mercapto-benzo-thiazole	0.8
Sulphur	1.2

—640-420, *Dunlop Rubber Co. Ltd., and E. S. Birbeck.*

Fuel gas manufacture

Hydrocarbon fuel gas is produced by passing a gas mixture containing carbon monoxide and hydrogen at conversion conditions conducive to the predominant formation of gaseous hydrocarbons, particularly methane, through a turbulent, dense, fluidised hydrogenation catalyst. The gas mixture is preheated to substantially the conversion temperature prior to its entry into the catalytic zone from which heat is withdrawn to maintain the desired temperature level. Normally, gaseous hydrocarbons are recovered. The feed gas may be obtained by gasification of solid carbonaceous material such as coal, coke, shale and the like, especially the residue from a carbonisation process operated according to the fluidised solids technique. Hydrogen may be added to increase the ratio to carbon monoxide from 1.3 to 3:1. The heat of solids removed from the gasification zone may be used to preheat the feed gas. This preferably enters the base of the converter, although part may be fed at a higher level. Products are withdrawn overhead, an enlarged separating space and mechanical or other separators for catalyst being provided.

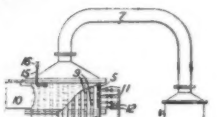
Suitable catalysts are iron group metals, and oxides or sulphides of Groups 5 and 6, alone or on carriers, especially nickel on kieselguhr.

Particles are preferably of less than 150, *e.g.* 5 to 100 microns, with not more than 60% of 0 to 20 microns. Superficial gas velocities of 0.1 to 2 ft./sec. and pressures up to 2,000 p.s.i. are suitable. Temperature varies from 500 to 700°F. Cooling medium may flow within the converter or fluidised catalyst may be withdrawn by standpipes, passed through a heat exchanger or directly contacted with cooling gas, and returned. At higher reaction temperatures, carbon must be burnt off from the catalyst by passing it, suspended in air, to an oxidation chamber of similar construction to the converter. If desired, it may be reduced with hydrogen in a further chamber, and returned to the converter. Two or more converters may be used in succession with intermediate removal of water, or part of the product gas may be recycled after water removal. Carbon dioxide may also be removed from the product.—640,907, *Standard Oil Development Co.*

Column-stills

In distillation columns the vapours are passed up through vertical elements such as tubes, the upper ends of which are surrounded by a liquid maintained in a casing.

The pressure within the casing is controlled by a valve in an outlet pipe from the vapour space of the casing so that the liquid therein boils. Heat is thus abstracted from the process vapours at such a temperature that a falling film of reflux liquid is maintained on the inside of each element. The level of the boiling liquid inside the casing may also be controlled.



The distilland is vaporised and led into column 1, the upper part of which contains vertical tubes 3. The upper ends of the tubes pass through casing 5 which is supplied with cooling liquid by means of pipe 10.

The vapour generated from the liquid boiling in the space between the tubes is led away through pipe 15 controlled by valve 16. The process vapours which are not condensed in tubes 3 are led by pipe 7 to the main condenser 8 of the system. Casing 5 is divided by means of foraminated plates 9 into several superimposed compartments, each of which is separately connected to one of a series of pipes 11 which lead, through valves 12, to manifold 14 and condenser 8. By these means the level of the liquid between the tubes can be varied, and the same liquid used as coolant in both condensers.—640,704, *A.P.V. Co. Ltd.*

World News

GREAT BRITAIN

New coal-handling plant

The coal-handling plant which is being supplied by Babcock & Wilcox Ltd. for Castle Donington power station will be one of the largest installations in the country, having a total handling capacity of 960 tons/hr. to the boiler-house bunkers, and a storage capacity in the coal store of more than ½ million tons.

The coal sampling arrangements are of particular interest. At the heads of the four incoming conveyors primary samplers of the *Geco* design are arranged. The primary samples proceed by chute to a sampler crusher, where they are reduced to pass a ⅛ in. mesh. Under the sampler crusher there is a secondary sampler, and the final sample is taken down into a collecting box on the sampler-house floor. The reject material is returned to the transfer hopper.

The two conveyors which take the coal from the transfer hopper are each fitted with a separated tandem drive, and transport the coal to a junction tower forming an extension to the bunker bay, a distance of about 420 ft., and deliver over-end at a height of approximately 125 ft. above ground level, on to two further conveyors which run over the bunkers the entire length of the boiler house. These are approximately 514 ft. between centres, and are fitted with automatic travelling trippers arranged for discharging coal into any of the six bunker pockets.

Hydromechanics research appointment

Mr. R. C. Worster has been appointed deputy director of research of the British Hydromechanics Research Association. He has been a member of the research staff since the formation of the Association.

Atomic power station project

Work has started on preparing the site for an experimental atomic power station on the Calder Hall site alongside the atomic energy establishment at Windscale, Cumberland. Some days after announcing this in the House of Commons, the Minister of Supply, in reply to a question, said that he was not at present prepared to commit himself to estimates of the completion date, the planned electrical capacity, or the cost. Discussions on finance are proceeding with the British Electricity Authority.

As mentioned in our last issue, the Windscale establishment produces plutonium from uranium.

Dangerous goods and explosives in ships—rules changed

The detailed rules for the carriage of dangerous goods and explosives in ships, which are set out in Appendix A to the Report of the Departmental Committee on the Carriage of Dangerous Goods and Explosives in Ships, 1951, need to be kept up to date in the light of current experience and to provide for the packing and stowage of new substances. Accordingly, amendments are to be published from time to time.

Amendments Nos. 1, 2 and 3 have already been published and can be obtained from H.M. Stationery Office, price 2d., 6d. and 4d. respectively.

New Institute of Fuel president

Dr. W. Idris Jones, Director-General of Research to the National Coal Board, will succeed Dr. G. E. Foxwell as president of the Institute of Fuel in October. Dr. Jones was once employed as a research chemist at Billingham with I.C.I. Here he made his first incursion into the field of fuel technology and, after some research work on the development of methanol synthesis catalysts, he became successively assistant manager of boiler and water-gas plants and, later, a group manager in the Coal Hydrogenation Division. In 1933 he was appointed director of research of Powell Duffryn Ltd., and at Ystrad Mynach he developed the group's research laboratories. The next 14 years brought him into contact with all aspects of fuel research: mining, coal preparation, briquetting, carbonisation and gasification and the working-up of tar products. He directed the research work on the development of the *Phurnacite* process and was closely associated with experiments on 'colloidal fuel' carried out in collaboration with the Cunard Steamship Co. In November, 1946, he was appointed to his present post, where he is responsible for co-ordinating the work carried out in the Board's research establishments at Stoke Orchard and Isleworth. He is a Welshman.

G. A. Harvey appointment

Mr. P. T. Bliss has been appointed sales director of G. A. Harvey & Co. Ltd. Mr. Bliss, who is a member of the Incorporated Sales Managers' Association and the Incorporated Advertising Managers' Association, joined the company in 1909, and has been sales manager for a number of years.

Fisons' experimental farms

Two farms at Levington, near Ipswich, have been acquired by Fisons Ltd. for experimental purposes. They total about 350 acres and will be converted to agricultural research laboratories under the direction of Dr. R. Stewart, chief agricultural adviser to the company. It is expected that about 70 scientists and technicians will be employed there.

Tests will be carried out on new fertilisers or other agricultural chemicals developed in the company's own laboratories. It is intended that the farms will form the nucleus of a series of experimental farms to be set up in other parts of the country.

The other research establishments of the Fisons group, engaged on medical and general chemical work, will not be affected by the plan.

Scientific Advisory Council's new chairman

Prof. Sir Eric Rideal, M.B.E., D.Sc., F.R.S., is to be chairman of the Minister of Supply's Advisory Council on Scientific Research and Technical Development in succession to Prof. Sir John Lennard-Jones, K.B.E., Sc.D., F.R.S. Sir Eric Rideal, who is professor of physical chemistry at King's College, London, has been associated with research work of the Ministry of Supply since the early part of the late war. He is a director of Monsanto Chemicals Ltd., and a former president of the Society of Chemical Industry.

The council was set up during the early part of the war to advise the Ministry of Supply on research and development problems concerned with defence. It was continued after the war and includes many eminent scientists, engineers and industrialists who advise on the important scientific and technical problems with which the Ministry is concerned.

Natural gas search

A large-scale search for natural gas is to take place in the U.K. in the near future. Discussions are proceeding between the Gas Council and the Anglo-Iranian Oil Co. with a view to explorations being carried out over a period of five years.

Announcing this recently, the chairman of the Gas Council, Col. Sir Harold Smith, pointed out that increases in the gas industry's coal and freight bill have totalled £18 million in the last 18 months and have given added impetus to the industry's search for alternative sources of gas supply. Before committing itself to any large-scale exploration plans, the Gas Council sought the opinion of Dr. G. M. Lees, F.R.S., chief geologist of Anglo-Iranian, and his advice proved favourable to the project.

Although there are no appreciable known reserves of natural gas in Great Britain, it is important to remember that so far when borings have been made they have been made with the object of finding oil, no serious attempt having been made to look for natural gas. One interesting possibility is that gas may be found separately from oil.

Last year an application to sink an exploratory borehole for natural gas at Whitby, Yorks., was made by I.C.I. This was briefly reported in CHEMICAL & PROCESS ENGINEERING, 1952, **9**, 507.

Continuous board manufacture

Recently, at Marks Tey, Essex, we saw in operation what is claimed to be the first machine in the world for making board from waste wood by a continuous process. Made by the Vere Engineering Co. Ltd., who are the sole agents for Great Britain, it will shortly be working to full capacity with an annual output of 16,000 tons or between 25 and 40 million sq. ft., according to the thickness of the board produced. The Bartrev press, as it is called, is an assembly of four essential parts: a feeding unit, a high-frequency heating unit for pre-heating the wood-resin mixture to 85 to 90° C. before compression, the press itself and an automatic saw.

Several processes, to meet the various conditions of raw material, have been developed. Pre-dried material which is already in relatively small pieces, *e.g.*, planer shavings, may need only grinding in orthodox hammer mills. Where the material occurs in pieces of large size, special machinery is used to convert the material into shavings, and if the material is wet, as is the case with much forestry waste, a subsequent drying process is necessary. In this way almost any unused wood can be suitably prepared. Air-swept mills and pneumatic driers form part of the pneumatic transport system, conveying the raw wood material to the resin-mixing stage. Once the raw material has been thoroughly mixed with the resin, the chemistry of the process begins. It is concerned primarily with the bonding of the wood material by the curing (polymerisation) of the resin. It is here that the foundations of the process flexibility are laid. Because of the short curing cycle, special quick-setting resins must be used. The proportion of resin to raw material varies from 5 to 8% according to the types of wood used and the properties required in the end product.

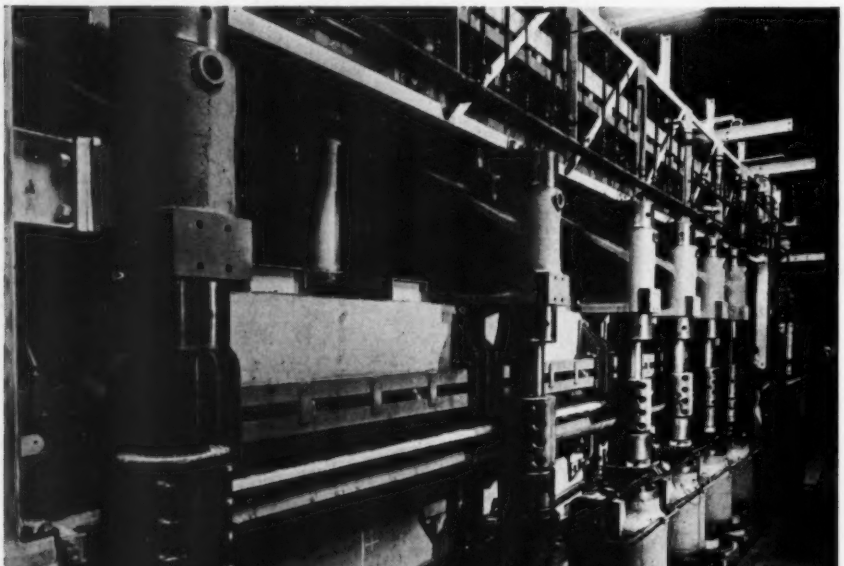
Sulphur returns still necessary

Although the Sulphur Committee in the United States has been dissolved, British manufacturers will still have to furnish the Ministry of Materials with particulars of the quantities of sulphur used. This was stated by the Minister in reply to a question recently. The information required has been reduced to the minimum and it has been found possible to dispense with returns from some 1,200 small users. Simplified quarterly returns are still necessary, however, from importers of sulphur and firms using sulphur in bulk, particularly in view of the continuance of America's control of exports.

New tar works plant contractors

A recently formed company, to be known as Proabd (England) Ltd., states that it is fully equipped for the design and manufacture of complete plant for the continuous distillation of tar, recovery of by-products, refining of solvents, extraction and refining of tar acids, production of naphthalene, benzole, toluol, light oils, etc.

The company is in technical liaison with Société Proabd of Nancy, France.



The pressure zone of the Bartrev press for making timber board, described on this page. The mixture of wood waste and resin is being compressed and cured between the two endless steel bands backed and supported by moving platen chains. The vertical pressure stanchions are set more closely together at the feed end to give a greater initial pressure. The board can be made any length and in thicknesses between $\frac{3}{16}$ and $\frac{3}{4}$ in. Its width is 4ft.

Our Contemporaries—July

Manufacturing Chemist — Particle Size : Its Measurement and Importance in the Chemical Industry; Chemotherapy and Selective Toxicity; The Vitamins; Odour Research, Part 2; The Manufacturing Chemist's Liability in Law for Negligence; Terramycin Production in England.

Atomics—Nuclear Instruments : A Survey; The Stomach Counter.

Food Manufacture—Canned Products Ltd. factory in Ireland; The Action of Vitamins; Pressure Cooking and Cooling.

Fibres—Seaweed and the Textile Industry, Part 1; Pulverising Machinery; Stripping Dyes from Waste Wool; New Zealand's Flax Industry; Palmyra Fibre and Bassine Production in South India.

Muck Shifter—The Place of Cranes in Muckshifting ; Kitimet Aluminium Project.

Building Digest—Lakewood Park Development Scheme.

Paint Manufacture—The F.A.T.I. P.E.C. Conference; Rheology of Paints; Optical Properties of Surface Coatings; The Effect of Driers on the Properties of Alkyd Resin Finishes.

Petroleum—A New Type of Flare Stack for British Oil Refineries; Lubricants for Engines and Industrial Equipment; Synthetic Gas Turbine Lubricants.

World Crops—Molybdenum in New Zealand Pastures; Agricultural Problems of the Niger Delta.

NORWAY

From cod to plastic

The Norwegian Government is expected to give financial aid to the amount of £108,300 to the fish firm Wm. A. Mohn & Son A/S of Bergen so that it can carry on with its production of plastic from cod-fish waste. The Governor of the Bank of Norway, the Minister of Industry, and technical experts have advised that the Government's North Norway Development Fund should make this grant. At its plant in the Lofoten Islands, North Norway, Mohn & Son A/S has for some time been producing the plastic experimentally, and the intention is to establish full commercial production at the rate of about 2,000 tons a year. The plastic is called *Monoplast*.

Niobium mine starts production

Extraction of ore containing the rare and valuable metal niobium has started at Söve near Ulefoss in Southern Norway. Nigeria is now one of the few other places in the world where this metal is mined. Niobium tolerates an exceptionally high temperature and is therefore much in demand as a constituent in alloys for jet and gas-turbine engines. The Söve mine, constructed by the Norwegian Government mining company, Norsk Bergverk A/S, at a cost of £100,000, will operate on a trial basis until July, when full production will start. It is hoped then to extract about 40,000 tons p.a. of raw ore containing an average of 0.3% niobium.

HUNGARY

Natural gas processing

A large chemical plant is being built in North-east Hungary in the region of the Tiszalök power project which will process natural gas piped into Hungary from Rumania, the Hungarian Press announces.

The pipeline will be laid by a joint Hungarian-Rumanian company, which will also be responsible for building a chemical plant at the Rumanian end. The Hungarian chemical plant, foundations for which were laid last June, is being built by Hungary alone.

Power will be supplied by the Tiszalök project, and the large quantities of water required will come from the reserves made available by the new Tisza barrage.

All work processes will be mechanised. The whole plant will be under central automatic control.

Preparatory construction work is going on this year and it will not be until 1955 that the main construction begins to take shape.

Million-ton steel works

The Lenin steel works at Diosgyör, North Hungary, will have an output of 1 million tons a year when it comes into full production in the near future, it is announced in the Hungarian Press.

Thus, from one plant alone, Hungary will get considerably more steel than all plants produced together in 1938 (647,500 tons). Overall production target for 1954 is 2,200,000 tons.

The Lenin works' new blast furnace, 215 ft. high, came into production at the beginning of this year.

SWEDEN

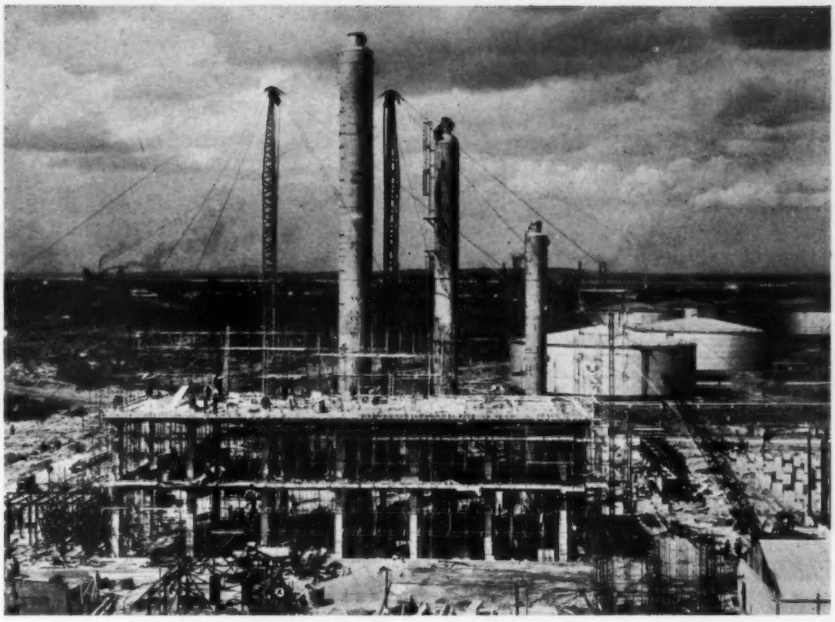
Siporex production plans

The Swedish lightweight building material *Siporex*, made from cement, siliceous sand, alumina and certain chemicals, is being introduced into the Western Hemisphere.

Internationella Siporex AB, of Stockholm, the patent holders, have signed licence agreements with firms in the United States, Canada and Mexico.

The U.S. Plywood Corporation has obtained the exclusive rights to manufacture this multi-purpose building material in the U.S. under the market name of *Zeprex*. In order to accelerate production, the company has acquired the business and assets of National Brick Corporation, the largest manufacturer of sand-lime bricks in the U.S. and also one of the major producers of concrete masonry units. Further *Zeprex* plants will be established throughout the country when the initial factory is in operation.

In Canada the big industrial group, Dominion Tar and Chemical Co., Montreal, has obtained the licence for the manufacture of *Siporex* throughout the Dominion and several factories are being planned.



First 'platformer' in U.K.

Now under construction at Stanlow Refinery, near Ellesmere Port, Cheshire, is the first 'platforming' (platinum catalyst) unit ever to be erected in the U.K. Estimated to cost £3½ million, it is scheduled for completion by the end of this year. By producing components for blending into high octane aviation spirit, the unit will increase overall output of this important fuel.

The installation of a 'platformer' at Stanlow, which also includes a modern chemical plant and a synthetic detergents plant among its facilities, serves to confirm the refinery's reputation as one of the most modern, fully-integrated oil refineries outside the U.S.A. It supplements a post-war expansion programme which has raised Shell's refining capacity in the U.K. from 1 million to nearly 9 million tons p.a.

The 'platformer' consists of three sections: feed preparation, reaction and stabilisation. In the first section a selected gasoline feedstock is purified and distilled to remove the light and heavy ends, the resulting 'heart-cut' being fed to the reaction section where it is heated and passed at a moderate pressure through a series of reactors containing platinum catalyst supported on inert material. The reactor products are cooled and the hydrogen formed in the reaction is separated, compressed and recirculated to the reactors with the feedstock. The liquid product is taken to the last section where the lighter fractions are removed by distillation and the so-called platformate is ready for blending into aviation spirit without further treatment.

Investigations in Mexico in the past few years have also shown that the prospects for production of this material are very good. Financial groups have founded a company called Siporex de Mexico S.A.

Siporex is claimed to be as weatherproof as stone, lighter than wood and capable of being sawn, hewn, nailed and bored. Its good insulating properties are said to make it suitable for all climates.

INDIA

Bricks from lime sludge

Investigations at the Central Glass and Ceramics Research Institute, Calcutta, have shown that good quality sand-lime bricks can be manufactured from lime sludge obtained from acetylene gas works.

Large quantities of lime sludge are obtained as waste product during the manufacture of acetylene from calcium carbide. An average-sized factory produces about 150 to 2,000 tons of this waste product per month.

Sand-lime bricks have proved superior to clay or red bricks for constructional purposes. Stronger and more regular in size and shape, they resemble white sandstone in appearance and are often employed as facing bricks to obtain artistic effects in buildings. By incorporating suitable pigments such as ochre, rouge, or lamp black, they can be made in a variety of pleasing colours.

SOUTHERN RHODESIA

Cement factory to be enlarged

The Premier Portland Cement Co. Ltd. is soon to erect a larger modern rotary kiln plant at its Bulawayo factory. With a fourth still larger kiln soon to be installed the annual capacity of the factory will be in the region of 260,000 tons.

TRINIDAD

New chemical enterprise

Industrial chemicals are to be produced locally by a new subsidiary company of Trinidad Leaseholds Ltd. Work on the installation of a $1½-million plant is progressing at Point-à-Pierre. Towards the end of this year production is expected to

begin of a range of chemicals including sulphur and sulphuric acid and chemicals used in the paints and plastic industries.

SOUTH AFRICA

Detergent production

Production on a commercial scale of the first of a series of synthetic detergents has been started by the Union Detergents Co. in association with the Savo Manufacturing Co. Ltd., chemical manufacturers of Johannesburg.

Only South African materials, labour and capital are being used. A large range of detergents is to be made in an attempt to meet the country's major requirements. Later, it is anticipated the products will be exported to other territories.

UNITED STATES

Monsanto increases phenolic resin output

Monsanto Chemical Co. has announced its third expansion of phenolic resin production in less than a year. An official of the company says that the expansion will add about 15% capacity to the local plant and the division's operations at Port Plastics, Ohio.

Two reasons were given for the decision to strengthen Monsanto's position as a phenolic resin supplier: (1) Widening markets for this type of plastic in the foundry, laminating and industrial fields, and (2) steady growth in Monsanto's share of the total market.

Platinum catalyst for new refining process

An agreement has been concluded between the Sinclair Refining Co., Baker & Co. Inc., and M. W. Kellogg Co. whereby Kellogg will offer the recently disclosed Baker platinum catalyst in a new process for the reforming of naphthas (low octane gasoline fractions) into high octane gasoline.

The catalyst, called *RD*-150, was developed through co-operative research by Sinclair and Baker. Of the regenerative type, it is claimed to have two major advantages over existing commercial platinum catalysts: (1) it maintains high activity over considerably longer periods of time, resulting in substantially lower catalyst operating costs, and (2) it has a greater ability to convert low octane paraffin components to high octane aromatic gasoline. Sinclair pilot runs are said to indicate that the new Baker catalyst can produce excellent yields of high octane product from a wide variety of feed stocks.

The new process for employing the catalyst will be of the fixed-bed type of a new design specially developed for this purpose. In this connection, Kellogg pointed out that its interest in the new catalyst and process does not affect its position in regard to its molybdenum catalyst reforming process, fluid hydroforming, which will continue to be offered for particular applications.

Baker & Co. is currently producing the new platinum catalyst in its Newark, N.J., plant. A new plant is being erected in New Jersey to produce vastly increased supplies to meet the expected demand for the catalyst.

Plant will make new higher alcohols

Archer-Daniels-Midland Co. is shortly to begin construction of a plant at Ashtabula, Ohio, which will produce unsaturated higher alcohols, many of which, the company says, are not at present commercially available.

The alcohols are claimed to have advantages over those currently on the market and are expected to be used in new types of detergents. It is hoped that they will also find a market in such products as vinyl plasticisers, shampoos, lubricating oil additives, corrosion inhibitors, anti-foam agents, anti-oxidants, agricultural chemicals, synthetic waxes and textile finishes. The plant will also produce glycerin and caustic soda as by-products.

New method of making propionic and butyric acids

Celanese Corporation of America has begun large-scale production of both propionic acid and butyric acid for sale to general industry in a new unit at the Pampa, Texas, plant. What is claimed to be an entirely new process is being used. This process, developed by the firm, involves a one-step oxidation of natural gas components to acetic, propionic and butyric acids and other chemicals yet to be announced, and is the first of its kind.

Propionic and butyric acid offer useful modifications of cellulose plastics. Other uses of these acids are in surface coatings, lacquers, flavours and pharmaceuticals.

Evaporation

(*Concluded from page 200*)

factured by the Powell Duffryn Carbon Products Company is illustrated in Fig. 7. In this construction the tubes are formed in a compact carbon block and the No. 1 unit has a transfer surface of 9.4 sq. ft. in a very small volume. These units can easily be assembled together to give increased surface. In commercial installations they have given good values of overall transfer coefficients. Thus a value of 200 has been obtained for concentrating thick fruit juice containing syrup and also for concentrating 40% sulphuric acid to 60%. A somewhat lower figure of 140 is obtained for sulphuric acid concentration from 60 to 74% at a pressure of 11 mm. of mercury, and similar values are obtained with spinning bath liquors and some pharmaceuticals.

These illustrations show the wide range of application of carbon and other non-metallic materials.

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